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RALPH L. HENNINGSON

will be author's acknowledgments

The Geological Formations of Manitoba

by R. C. WALLACE
Professor of Geology & Mineralogy
University of Manitoba

Published by
The Natural History Society
of Manitoba

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EXTRACT

Extract from the Constitution of the Natural History Society of Manitoba:

"The objects of the Society shall be: To foster an acquaintance with and a love for nature; to study especially the natural history of the Province of Manitoba; to encourage investigation and to publish the results of original research in all departments of natural history."



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PREFACE

This bulletin has been prepared at the request of the Natural History Society of Manitoba, and is published by that Society. Its purpose is to give a succinct summary of our knowledge of the geological formations of Manitoba, and thus to serve the needs not only of the student of Geology, but of the men and women of the province who may be interested in contributing to the advancement of the science by field observations in the district in which they live. In the hands of the teacher, it may also serve a useful purpose in the schools, in stimulating an interest on the part of the pupil in the history of those earth forms with which he is familiar. The appended bibliography is reasonably complete, and will be useful to students who wish to deal with any phase of the subject in greater detail.

The author is indebted to Professor V. W. Jackson and to the Department of Education for permission to use the map of South-western Manitoba (glacial), and to Mr. Rudolph Hiebert of the Department of Geology of the University for the preparation of the fossil drawings and the sections of Manitoba, and for assembling the bibliography. He desires also to express his appreciation of the courtesy extended by the Director of the Geological Survey of Canada in permitting the use of Map 55A, which will be found in the pocket attached to the cover of the bulletin.

Department of Geology,
University of Manitoba,
May, 1925.

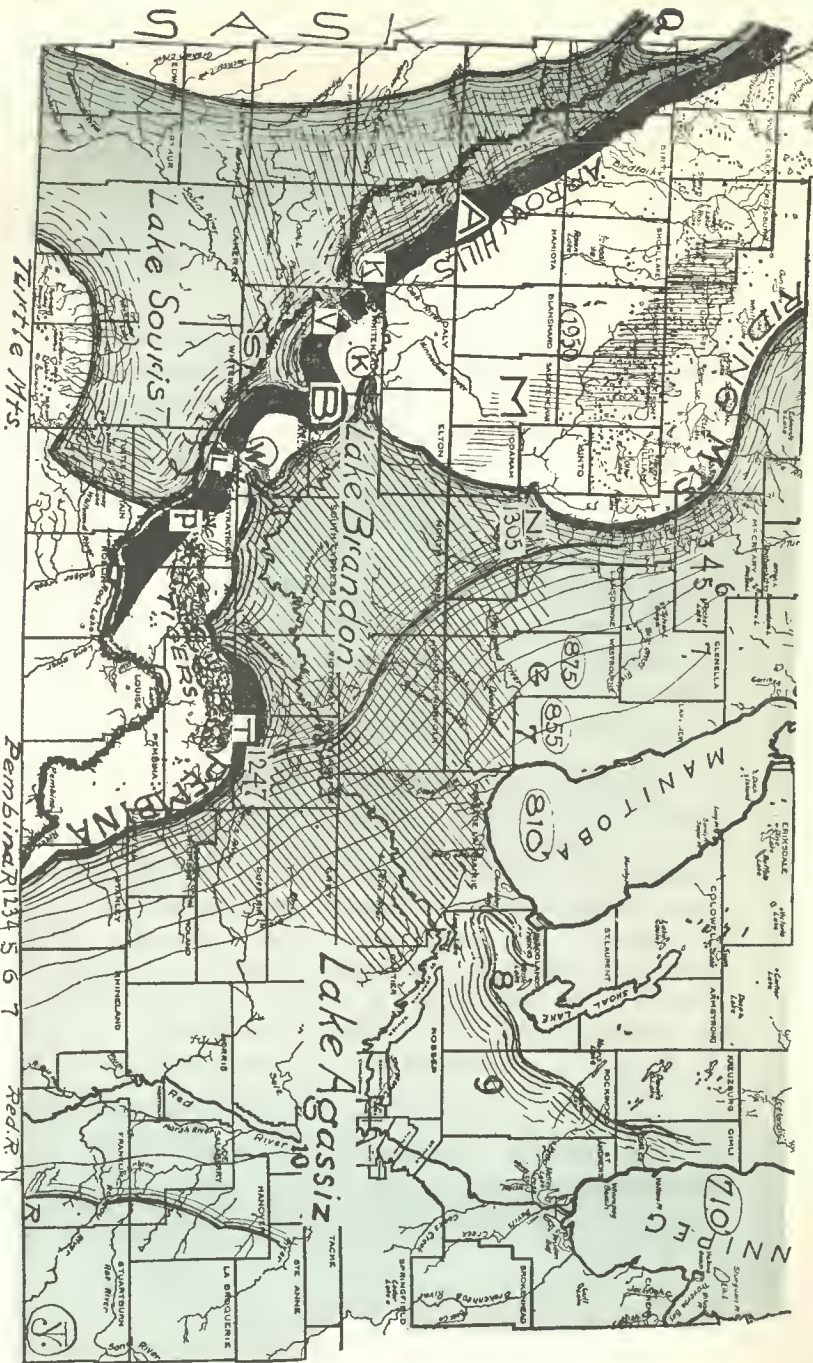


PLATE I—MAP OF GLACIAL GEOLOGY OF SOUTHERN MANITOBA

A K V B L P—Terminal moraine and northeast shore of Lake Souris. A—Arrow Hills. K—Kemnay break through. V—Big Slough or south flow of Lake Brandon. B—Brandon Hills. W—Wawanesa. I—Lange's Valley. P—Pelican Lake. T—Treharne corner of the Pembina. P—T—Tiger Hills. G—S—P—The Early river along the terminal moraine (Ojibwa-Souris-Pembina). M—Minnedosa moraine. N—T—Neepeewa-Treharne ridge (eastern limit of Lake Brandon. 1—7—Successive beaches. 1—4 The Upper Herman beach, 1,305 alt., three miles west of Neepeewa. 3—The Arden ridge or Cambell beach, 1,084 alt. 6—The Gladstone beach, 975 alt., at G. 7—The Burnside beach, 855 alt. 8—The Arzyle or Oswald ridge. 9—The Stonewall beach. Oblique shading—Delta sands.

THE GEOLOGICAL FORMATIONS OF MANITOBA.

I. INTRODUCTION.

Observations were made from time to time on the topography and geological formations of Manitoba by the early explorers, De la Verandrye (1734-1739), Pond (1778-1790), Thompson (1793-1805), Henry (1799-1808), Fidler (1794-1809), Harmon (1800-1819), Keating (1823), Franklin (1819-1827), Richardson (1819-1851), Palliser (1857), S. J. Dawson (1858), and Hind (1857-8). From 1873, more than half a century ago, with the work of G. M. Dawson, Bell and Spencer, and later Tyrrell, Dowling and Upham, there was initiated that systematic investigation by the Geological Survey of Canada, which has continued, under the later auspices of the Geological Survey and Mines Branches of the Department of Mines, to the present time. While very important observations were made by the early explorers they were necessarily isolated. Continuous work in the interpretation of the geology of the province may therefore be considered to be confined to the last fifty years, or somewhat more. It may be advisable by way of introduction to give a short statement of the result of that work.

There are many gaps in the geological column in Manitoba. The formations represented are the PreCambrian; Ordovician, Silurian and Devonian; the Cretaceous and early Eocene; the Pleistocene and Recent. Of these four groups the first is dominantly igneous, the second limestones and dolomites, the third shales, and the fourth clays, sands and lake deposits. Cambrian deposits may possibly be concealed under the Ordovician limestones, but it seems clear at least that during the long time represented by the Carboniferous, Permian, Triassic and Jurassic in other areas, the Manitoba area was entirely above the sea: and that during the relatively shorter time represented by the Oligocene, Miocene and Pliocene no seas or lakes invaded Manitoba. The glacial (Pleistocene) deposits were in part due to ice movement and subglacial water flow, and in part to deposition in lakes hemmed in by the ice

as it finally retreated northwards; and the postglacial (Recent) deposits to river erosion, lake silting, and peaty growth since those glacial lakes have emptied out.

There are then four main time intervals in the geological history of Manitoba during which contributions have been made to the rocks now to be found in the province. The first is out of all proportion the longest in time value—the PreCambrian. It involves a complicated sequence of volcanic activity, sedimentation, mountain building and denudation on a vast scale—it may be not once but twice, with the final planing down of the high relief to a peneplain with but few elevations left. The rocks, both igneous and sedimentary, have been considerably metamorphosed by the intense pressure reactions during the period of mountain building. With the close of the PreCambrian there came to a close in Manitoba volcanic activity, and attendant mountain building (orogenic) processes. Since PreCambrian times there has been a continuous succession of periods of quiet sedimentation, and of elevation and erosion. The movement of elevation or sinking has been of the epeirogenic (continent-forming) type which has scarcely disturbed the horizontality of the sediments during the process of movement. Accompanying those movements there has been no volcanic activity.

As the PreCambrian peneplain sank underneath the ocean, there was laid down a series of limestones which today flank the PreCambrian on its western margin, and at Hudson bay. This represents the second epoch in the history of deposition in the province. The Palaeozoic seas, which may have covered the major part of the PreCambrian country now exposed, and which may have extended over what are now the western plains, were rich in invertebrate life; and the limestones, dolomites and associated shales of Ordovician, Silurian and Devonian age exposed in the region of the larger lakes of Manitoba are the repository of the richest and most varied fauna which the rocks of the province contain.

The limestones were elevated and remained long exposed to erosive agencies. From the beginning of Carboniferous times to the end of the lower Cretaceous times there is no record of deposition in Manitoba. In upper Cretaceous times, however, not only western Manitoba, but the western plains as a whole, were covered by muddy oceans or inland lakes in which great thicknesses of shales and sandstone were laid down. It was not to be expected

that under such conditions life could flourish so abundantly as in the clearer seas of Palaeozoic times. There are calcareous bands in the shales which are fairly rich in invertebrate remains; but on the whole the Cretaceous beds are relatively poor in traces of the life of that time. Deposition seems to have continued in Manitoba into Eocene times, as it did in southeastern Saskatchewan, practically without a break. From late Eocene times onwards, traces of depositions are lacking, and the elevated shales were readily attacked by the erosive agencies which have had practically full play since that date.

The last stage in deposition was the result of the southward progress of the ice sheets of Pleistocene times. As a result of their erosive activity, there have been deposited on the surface of the older rocks boulders and eskers, moraines, drumlins and glacial till, while in the great glacial lake (lake Agassiz) which formed on the southward margin of the retreating icesheet bedded clays were deposited; and beaches were formed along the margin of the lake during the successive halts in the lowering of the lake surface. In Recent times rivers have cut their way through the glacial clays, lakes have to some extent been silted up, and extensive peat bogs have been formed on the surface of the glacial deposits. The topography of the country has on the whole been only slightly modified since glacial times.

In order to make more intelligible this short outline of geological changes in Manitoba which it was felt advisable to include in an introductory chapter before entering into a discussion of each period in detail, there is subjoined a table showing the main divisions of geological time, with the formations known to occur in Manitoba indicated in parallel table.



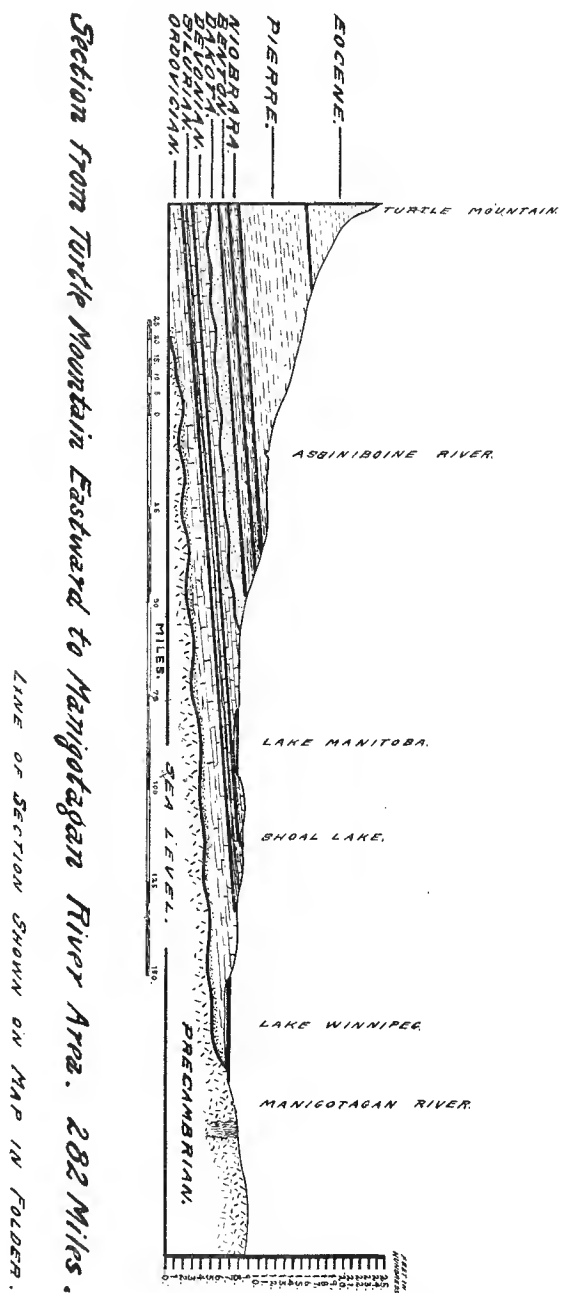


PLATE II
 Geological Section of Southern Manitoba
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	PERIOD.	EPOCH	EPOCH IN MANITOBA.
CENOZOIC ERA	QUARTERNARY	Recent Pleistocene	Recent Pleistocene
	TERTIARY	Pliocene Miocene Oligocene Eocene	Eocene
MESOZOIC ERA	CRETACEOUS	{ Upper Cretaceous Lower Cretaceous	Upper Cretaceous
	JURASSIC	{ Upper Jurassic Middle Jurassic	
	TRIASSIC	{ Lower Jurassic	
PALAEOZOIC ERA	PERMIAN CARBONIFEROUS	{ Pennsylvanian Mississippian	{ Upper Devonian Middle Devonian Upper Silurian (?) Middle Silurian Lower Silurian Upper Ordovician Middle Ordovician Upper Cambrian Middle Cambrian Lower Cambrian
	DEVONIAN	{ Upper Devonian Middle Devonian Lower Devonian	
	SILURIAN	{ Upper Silurian Middle Silurian Lower Silurian	
	ORDOVICIAN	{ Upper Ordovician Middle Ordovician Lower Ordovician	
	CAMBRIAN	{ Upper Cambrian Middle Cambrian Lower Cambrian	
PRE-CAMBRIAN		Keeweenawan Animikie Algoman Temiscamian Laurentian Keewatin	Algoman Temiscamian Laurentian (?) Keewatin

II. THE PRECAMBRIAN.

Rocks of PreCambrian age are exposed in the eastern and northern parts of Manitoba. West of lake Winnipeg they are overlain by younger sediments; while immediately west of Hudson bay sediments of Palaeozoic age conceal the PreCambrian rocks. They are the surface formation in somewhat more than three-fifths of the total area of Manitoba; though the rock itself may be concealed to a large degree by soil, forest cover, or glacial clays. The western boundary extends from the southeastern corner of the province northwestward to lake Winnipeg, which is an erosion lake between the PreCambrian and the overlying limestone, northwestwards from the north end of lake Winnipeg to the Grass river, which with its lakes lies in or near the boundary up to its source, thence along the south side of Athapapuskow lake to the western boundary of Manitoba. The overlying Ordovician limestone stands out as a sharp scarp over a considerable part of this line, showing occasionally at its foot the PreCambrian floor. The Palaeozoic formations which, to the northeast, along the west side of Hudson bay, overlie the PreCambrian rocks, are exposed only rarely along the river channels, and are themselves covered by a great thickness of glacial drift. The boundary line is seldom seen, and is nowhere marked by a definite scarp as is the western boundary. It is drawn in a somewhat provisional way, pending more detailed work in that distant region.

The PreCambrian is the most complicated of the geological formations in Manitoba. It has been mapped in detail in only a few areas; and it has not been yet possible to correlate satisfactorily the results from the several fields. Much more work will be necessary before a reasonably complete picture can be obtained of the succession of events of major significance that took place in Pre-Cambrian times, and over an immense period of time. Much arduous work has been done; and for practically the whole of the mapping of this large and inaccessible part of the province officers of the Geological Survey have been responsible. The intensive work which has been done in the mining areas in Ontario has been of assistance in throwing light on the problems of Canadian Pre-Cambrian geology as a whole.

In the earlier work, it was believed that the granites and gneisses that form such an important part of the PreCambrian rock formations were the basement—the fundamental complex—on which all other PreCambrian rocks had been laid down. The classical work of Lawson in the Lake of the Woods area in 1885 gave conclusive proof that there was an older rock than the granites and gneisses, a greenstone or altered lava, named by Lawson "Kewatin" into which the Laurentian granites had been intruded. The

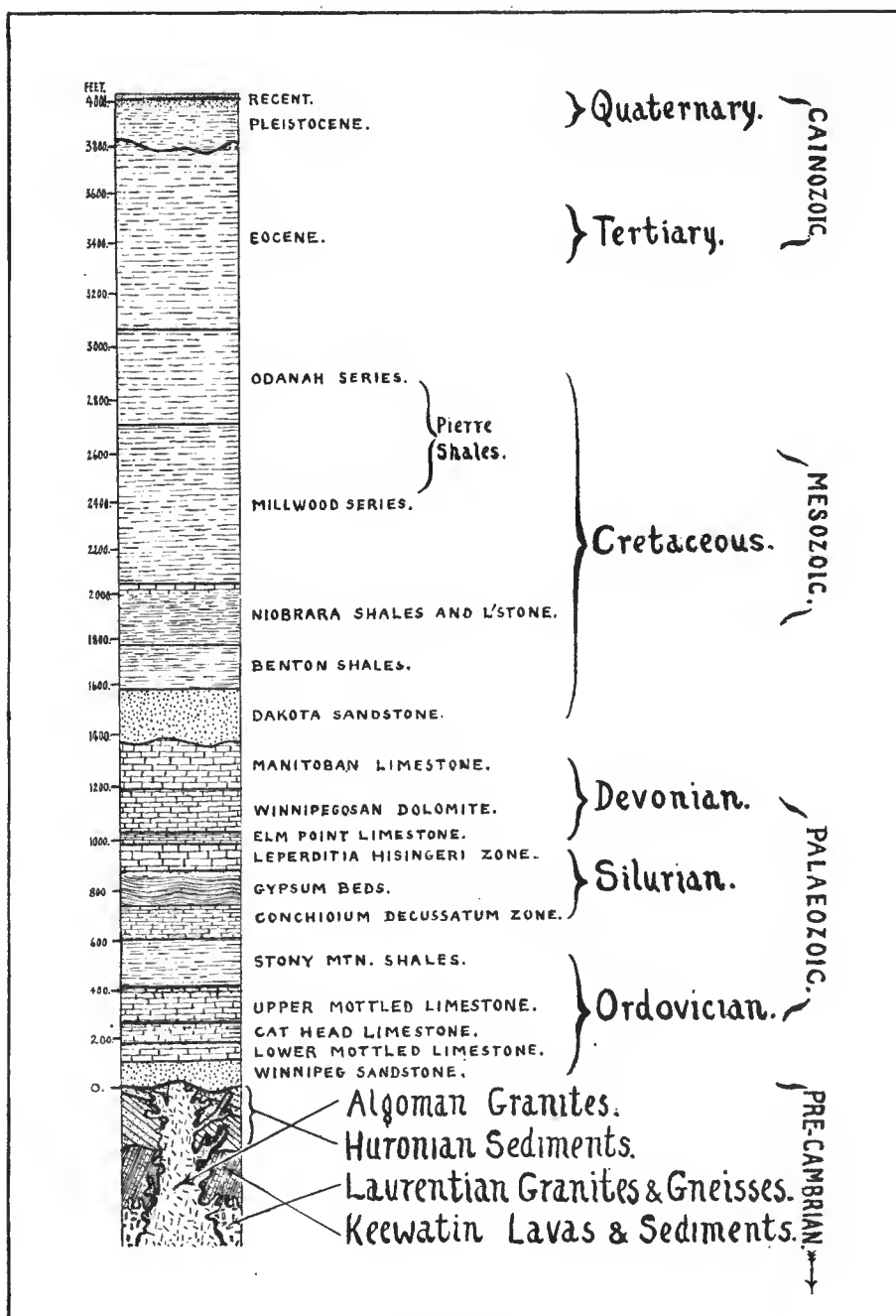


PLATE III

Column of Geological Formations in Manitoba

basement on which that ancient lava had been poured out has not been found—it has been swallowed up in the granite which later invaded and intruded basement and lava alike. Further detailed work in the Canadian PreCambrian showed that much of the granite which had been considered to be of Laurentian age was much younger, and that a second great period of plutonic activity and mountain building had taken place after the mountains of the Laurentian upheaval had been planed down by the agencies of denudation. This second period of orogenic activity was called by Lawson the "Algoman" revolution, and the granites of that age now exposed, the Algoman granites.

As work proceeds in PreCambrian areas, the exposed granites are being referred in greater measure to this later mountain-building period; and in all the areas which have been worked out in any measure of detail in Manitoba, the occurrence of granite of the earlier period is problematical, except such as may occur in the form of granite pebbles in conglomerates which were invaded by the later granite. Associated with the later granites in geographical distribution, and apparently fairly closely associated in time, are gabbros, norites and lamprophyric dykes. In the great mountain building movement a differentiation of the plutonic magma may have taken place, in part at least, into acid and basic phases.

The present day practice in PreCambrian work is to propose purely local classifications for each particular district, and to avoid the danger which lies in any attempt to correlate these classifications. It is therefore a somewhat doubtful expedient to submit a PreCambrian classification for the province. For the sake of clearness of discussion, however, the attempt is made, with the proviso that the formational names are submitted in a purely tentative way. The emphasis is on the time sequence of events, not on the correlation with formational terminology current elsewhere.

PreCambrian Formations in Manitoba.

- | | |
|---|----------------------------------|
| E. Granite intrusions | |
| Gabbro intrusions. | Algoman (?) |
| Lamprophyric dykes. | |
| D. Arkose, conglomerates with large
jasper pebbles. | |
| Minor unconformity. | |
| C. Quartzites, slates and greywackes. | |
| Conglomerates with pebbles, mainly
of granite, aplite and felsite. | Temiscamian (?) |
| Erosional unconformity. | |
| B. Lit-par-lit intrusions of granite, now
gneissose. | Laurentian (?) |
| A. Basic and acid lavas with basal and
interbedded sediments. | Keewatin and
Coutchiching (?) |

This table is drawn up to represent a complete succession of PreCambrian rocks in Manitoba territory, and is consequently much fuller than can be illustrated from any single district. There is considerable doubt as to the validity of the position of (B) in the table. There are gneissose intrusions into the altered lavas (greenstones) older than the main granite intrusions (E), and which may be of age (B). The only indication of their being older than the conglomerate (C) is the presence of pebbles of similar gneiss in the conglomerate, and that evidence is not conclusive. The facts will be better established when more systematic work has been done in the great granite areas of the PreCambrian. It has been suggested as well that rocks of Keweenawan age (the latest stage in Pre-Cambrian times) may find a place in the Manitoba table. Amygdaloidal lavas with zeolitic infillings and traces of native copper occur in a small outlier of PreCambrian age in the Palaeozoic terrain near lake St. Martin. Lithologically they show considerable resemblance to the Keweenawan lavas of northern Michigan, but the limited exposure does not provide sufficient evidence to determine the age of the lavas and the associated tuffs. As there is some indication that the tuff beds were hardened by a granite which was probably of age (E), the Keweenawan member is not inserted in the above table.

The early reconnaissance work was done by Bell, Cochrane, Low, McInnis, Tyrrell and Dowling. As elsewhere in the Canadian PreCambrian the detailed work has been done in Manitoba in areas which are of economic significance on account of the mineral deposits which they contain. Detailed mapping has been carried out in two areas (1) the area north of The Pas, from the Manitoba-Saskatchewan boundary near Schist lake, eastward to Wekusko lake by Bruce and Alcock of the Geological Survey of Canada; and (2) the area east of lake Winnipeg from Wanipigow river southward to Lac du Bonnet by several workers, but most recently and in detail by Wright of the Geological Survey of Canada. Other areas that have been examined in lesser detail are the Cross lake and Pipestone lake area, the Oxford lake and Knee lake area, the Nelson House and South Indian lake area, the Lower Churchill river area, the area between the Whitemouth river and the Winnipeg river south to Star lake and Falcon lake.

A tentative correlation of the work in the various fields has been given by Alcock and Bruce. In general terms, the lavas of age (A), frequently ellipsoidal and always much altered, are associated with sediments which are usually younger, but in some cases (Knee-Oxford lake, Narrow lake) in part older, than the lavas. The older sediments may be tentatively correlated with the Couchiching mica schists of Lawson in the Rainy lake area. In some areas the younger sediments are coarse, even conglomeratic, in others the fine sediments have been highly metamorphosed, with the development (Wekusko lake) of garnet, andalusite, staurolite and kyanite. The basic lavas are normally older than the acid lavas, and are characterised by the development of chlorite, while

sericite is the common product of metamorphism in the acid types.

Granites of age (B) are everywhere doubtful, and in some areas are definitely not to be found apart from the pebbles which occur in the conglomerates of age (C), and which may possibly be derived from a still earlier granite. Certain lit-par-lit intrusions of an acid sheared grey granite into the greenstones seem definitely older than the granites of age (E) and may represent the so-called Laurentian granite

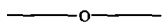
The conglomerates of age (C) are the result of intense erosional activity, and have been highly sheared and intensely folded since deposition. The pebbles are of granite, gneiss, felsite, greenstone and, more commonly, quartz. In some areas there are associated fine-grained sediments now infolded with the conglomerates. In only one area (Athapapuskow lake) has a second conglomerate been found (age (D)) separated by an unconformity from the earlier conglomerate just described. This younger conglomerate is characterized in places by the occurrence of large jasper pebbles, and by a flatter attitude than that shown in the older conglomerate. With the conglomerate is associated arkose, and the whole sedimentary phase represents disintegration and sorting of a local type.

The granites of age (E) are now, as a result of the denudation that has taken place since their intrusion, the dominant rock type throughout PreCambrian territory. They are normally fresh, massive biotite or hornblende granites, but there are associated as well older gneissose and more basic varieties, as well as younger pegmatites. There is evidence in all the areas that a complex of granite crops was intruded, probably over a long period of time, as a result of the vast mountain building movement which took place. The basis plutonics and hypabyssal types are represented in the Cross lake area and elsewhere by diabase dykes, and in their most important occurrence in the Maskwa river and Oiseau lake areas by batholiths of gabbro. Many of the diabase dykes are later than the main granite intrusion, and may correspond in age to the Nipissing diabase of Ontario, of possibly Keweenaw age. The gabbro batholiths of the Lac du Bonnet area on the other hand have been found by Cooke and by Wright to be earlier than the youngest granites of that area. There are therefore basic types both earlier and later in age than the main granitic intrusions. To what extent they may represent differentiates from the acid magma must yet be determined.

The formations hitherto described, in all of which the granites of age (E) are intrusive, have suffered intense erosion subsequent to their intrusion by granites and elevation into mountain ranges. In the planing down of these mountains, the earlier formations have been worn away except in the deeper hollows where now lie the river valleys and lake expanses.

From the economic standpoint, the PreCambrian formations in Manitoba have received considerable attention, particularly in the areas above referred to, where detailed mapping has been carried

on. The granites of age (E) have been responsible for the introduction of gold in quartz veins and shear zones in the surrounding rock, particularly in the sheared lavas of age (B). Gold is found from Athapapuskow lake eastward to Wekusko lake; on Knee lake; from Hole river lake southwestwards to Bulldog lake, near the Ontario boundary, on Star lake and Falcon lake, west of the Lake of the Woods. From the same series of granites, sulphides of iron, copper, lead and zinc have invaded and metasomatically replaced mashed greenstones in shear zones and drag faults in Schist lake—Athapapuskow lake areas. Sulphides of copper and nickel are associated with the granites and gabbros in the Maskwa river—Oiseau lake areas; and scheelite and molybdenite are associated with pegmatites which probably represent a late stage in the plutonic activity represented by (E) in the Star lake area. Banded haematite and magnetite occur in the sediments which are grouped under (A), but they have not yet been found to be of economic importance. A reference to one of those occurrences on Knee lake, by Edwards in 1812, is the earliest statement with reference to metallic mineral deposits on record for the territory now included within the boundaries of Manitoba. The mineral deposits in Pre-Cambrian territory have been dealt with in two provincial bulletins, one by Wallace, for Northern Manitoba, the other by DeLury, for South-eastern Manitoba.



III THE PALAEOZOIC ERA

(a) *The Ordovician Period.*

The PreCambrian surface on which the Palaeozoic sediments were laid down had been smoothed by erosion before Ordovician times to a peneplain somewhat of the type that it shows at the present time. The smoothness of the boundary line between Pre-Cambrian and Ordovician formations, as now mapped, would not have been possible had the PreCambrian surface on which the Ordovician sediments were laid down been one of high relief, and the uniform level of the PreCambrian floor at the base of the Ordovician limestones gives direct evidence on this point. That the final stage of peneplanation had not been reached is shown by an outcrop of PreCambrian rock near lake St. Martin at a place where the PreCambrian surface, if reduced to a peneplain, should be covered by at least 600 feet of later sediments. There was therefore a hill standing 600 feet above the level of the PreCambrian surface when the Palaeozoic seas invaded this territory. Such differences of relief are not found in the present day PreCambrian surface in Manitoba.

The principal exposures of Ordovician age are the cliffs on the west side of lake Winnipeg. From them, and from isolated exposures in the Red river valley, including Stony Mountain and East Selkirk, Dowling worked out a sequence for the Ordovician in Manitoba as follows:

Manitoba	Minnesota, Iowa, and Wisconsin
Stony Mountain Shales (190 ft.)	Maquoketa Shale.
Upper Mottled Limestone (130 ft.)	
Cat Head Limestone (70 ft.)	Galena Dolomite
Lower Mottled Limestone (70 ft.)	
Winnipeg Sandstone (100 ft.)	Green Shales (Black river.) Plattsville Limestone. St. Peter's Sandstone.

The scarcity of fossils in the basal member, the Winnipeg sandstone, makes the correlation with Ordovician rocks to the south a matter of some difficulty. The suggested correlation with Black river shales was made on the basis of some fossil material from the top shaly beds of the Winnipeg Sandstone. There is a possibility that the sandstone beds are to be correlated with the St. Peter's Sandstone, with which they are lithologically more nearly similar. It has even been suggested that they may represent the Potsdam Sandstone of late Cambrian times, though not on the basis of any palaeontological data.

Winnipeg Sandstone.

The Winnipeg sandstone has few exposures in the Ordovician outcrop on lake Winnipeg and to the northwest. As the rock is readily disintegrated, scarps are rare. The sandstone varies in thickness from 100 feet to zero, the thickness depending to a great degree on the inequalities of the floor. In many exposures, particularly towards the north, the sandstone is absent, and limestones of Lower Mottled age are seen to rest directly on the PreCambrian floor. The most important exposures of the Winnipeg sandstone are at Elk island, Grindstone point, Little Grindstone point, Black island and Punk island on lake Winnipeg, and on Simon-house lake south of the Cranberry lakes on the Grassy river. The formation is an unconsolidated or partially consolidated sand, occasionally deeply stained by iron but otherwise practically pure silica, frequently showing crossbedding, but nowhere a conglomerate base. The sandstone grades upwards into a more argillaceous phase, with clayey partings. It is in this upper phase that a few fossils are found, which would apparently correlate that phase with Black river shales, the lower beds are unfossiliferous, and may be of considerably earlier age. The species are *Licrphyucus ottawaensis*, *Serpulites dissolutus*, *Rhinidichtya mutabilis*, *Escharopora ramosa*, *Strophomena trilobata*, *Orthis testudinaria*, *Cyrtodontia canadensis*, *Aparchites tyrrellii*, *Conularia* sp.

The conditions which made possible the deposition of sand in irregular basins in the early Palaeozoic seas, without conglomeratic phases, are difficult to interpret. The sea in all probability advanced from the north and covered the area between Hudson bay and lake Winnipeg where now the PreCambrian rocks are exposed. It would appear that the erosion of the peneplain by the

advancing sea was not extensive, else conglomerates would be seen, and limestones would not rest on the PreCambrian base, without intervening coarser sediment. There was probably a rapid advance of the sea over a surface which had been subjected to long continued subaerial erosion and conditions intervened which early gave rise to the deposition of calcareous ooze from the disintegration of the shells of the invertebrate animals which so abundantly populated those seas

Lower Mottled Limestone

The Lower Mottled limestone rests on the shaly upper beds of the Winnipeg sandstone. The main exposures are at Grindstone point, Bull head, Dog head, Black Bear island, Tamarack island and Jack Head island on lake Winnipeg. The argillaceous limestones which rest directly on the PreCambrian floor in Wekusko lake, Cranberry lake and Athapapuskow lake are probably of this age. Near its base the formation is argillaceous, but elsewhere a yellowish or buff-coloured limestone, characterized by darker brown spots which give the speckled or mottled appearance to the limestone. The total thickness is estimated at 70 feet, and the richest horizon in fossils lies immediately above the argillaceous limestones at the base of the formation. The Lower Mottled limestones, like the succeeding members of the Ordovician system, are highly fossiliferous, and, like the Upper Mottled limestone, in particular, are characterized by the presence of very large types. Sixty-eight species have been identified from this formation, mainly cephalopods, gastropods and pelecypods. The following are some of the most abundant: *Receptaculites Oweni*, *Streptelasma robustum*, *Stromatopora canadensis*, *Orthis subquadrata*, *Endoceras subannulatum*, *Cyrtoceras laticurvatum*, *Asaphus susae*, *Ilaenus americanus*

Cat Head Limestone

The Cat head limestone is exposed at Cat head, McBeth point, Inmost island, Outer Sturgeon island, Howell point and Robinson point on lake Winnipeg. The rock of this formation, which is estimated to be 68 feet thick, is more dolomitic than is the Lower or Upper Mottled limestone, and does not show the mottling characteristic of the limestones which underlie and overlie it. The Cat Head limestone is recognized by the chert nodules, some of them of large size, which are found throughout the beds, but particularly at the base of the formation. The cherts are distributed in horizontal bands, flattened along the bedding planes. They may represent the infillings into cavities left by the solution of large corals, on the other hand, they may have been formed by precipitation. Owing to the abundance of the nodules, the silica percentage of this horizon is unusually high for Palaeozoic limestone. The top beds are porous, honeycombed dolomites. Forty-nine species of fossils have been determined from the Cat Head limestones. The large cephalopods of the Lower Mottled limestones are not found, but the beds are unusually rich in fucoidal markings, four species of *Chondrites* having been determined. The following

are some of the fossils: *Chondrites gracillimus*, *Chondrites cuneatus*, *Lingula elongata*, *Raphinesquina lata*, *Maclurea manitobensis*, *Asaphus gigas*.

Upper Mottled Limestone.

The Upper Mottled limestone is exposed on the west shore of lake Winnipeg north of the mouth of the Saskatchewan river and on Selkirk island near Clark point, at Dancing point, near the mouth of the Dauphin river, at East Selkirk, Garson, Lower Fort Garry, St. Andrew's Locks, and east of Fisher Branch. The thickness is estimated at 130 feet. As the rock is exposed near Winnipeg, and as it is widely used as a building stone, the Upper Mottled limestone is much better known than the other formations of the Ordovician. The rock is a very decidedly mottled light grey limestone, the darker rounded patches being either buff or blue in colour. Wallace has shown that the darker areas are much more highly dolomitised, and are in all probability due to contemporaneous dolomitisation set up on disintegration of fucoidal material. Lithologically, the Upper Mottled limestone differs from the Lower Mottled limestone mainly in its chalky nodules, which can be picked out by the finger from the lighter coloured parts of the rock. The quarries at Garson (Tyndall) and the abandoned quarries at East Selkirk give sections which are easily available for study. The quarry beds, together with a drill hole, give a section of 97 feet in the Upper Mottled rock, the lower 62 feet of which is so thin bedded as to be valueless as a dimension stone, and is much more argillaceous than the quarry beds. Seventy-five species of fossils have been determined from the Upper Mottled limestone, among them very large cephalopods, and compound corals also of exceptional size. It is difficult to select dimension stone which does not show some evidences of the extraordinary development in size of the faunal species of this time. Among the commonest are the following: *Receptaculites oweni*, *Halysites catenularia*, *Columnaria alveolata*, *Streptasma rusticum*, *Favosites prolificus*, *Raphinesquina lata*, *Maclurea manitobensis*, *Orthoceras Selkirkense*, *Ilaenus americanus*.

Stony Mountain Shales.

The Stony Mountain shales and limestones, of an approximate thickness of 110 feet, are partly exposed at Stony Mountain and Little Stony Mountain, near the City of Winnipeg. East of Fisher Branch, in deep ravines south of Fisher river, some of the red shale beds are seen. At Stony Mountain the upper 41 feet of the formation is exposed, consisting from the top to the bottom of 14 feet of buff-coloured limestone (the quarry beds), 15 feet of yellow argillaceous limestone full of fossil casts, and 12 feet of red shales very rich in fossils. Beneath that a speckled reddish limestone continues as determined by drilling for 60 feet, when a harder solid bedded limestone is reached which may represent the top beds of the Upper Mottled limestone. The top quarry beds are also exposed at Little Stony Mountain. These quarry beds are not highly fossiliferous, but contain very large specimens of *Beatricea nodulosa* and *Beatricea undulata*; and on the floor of the quarry

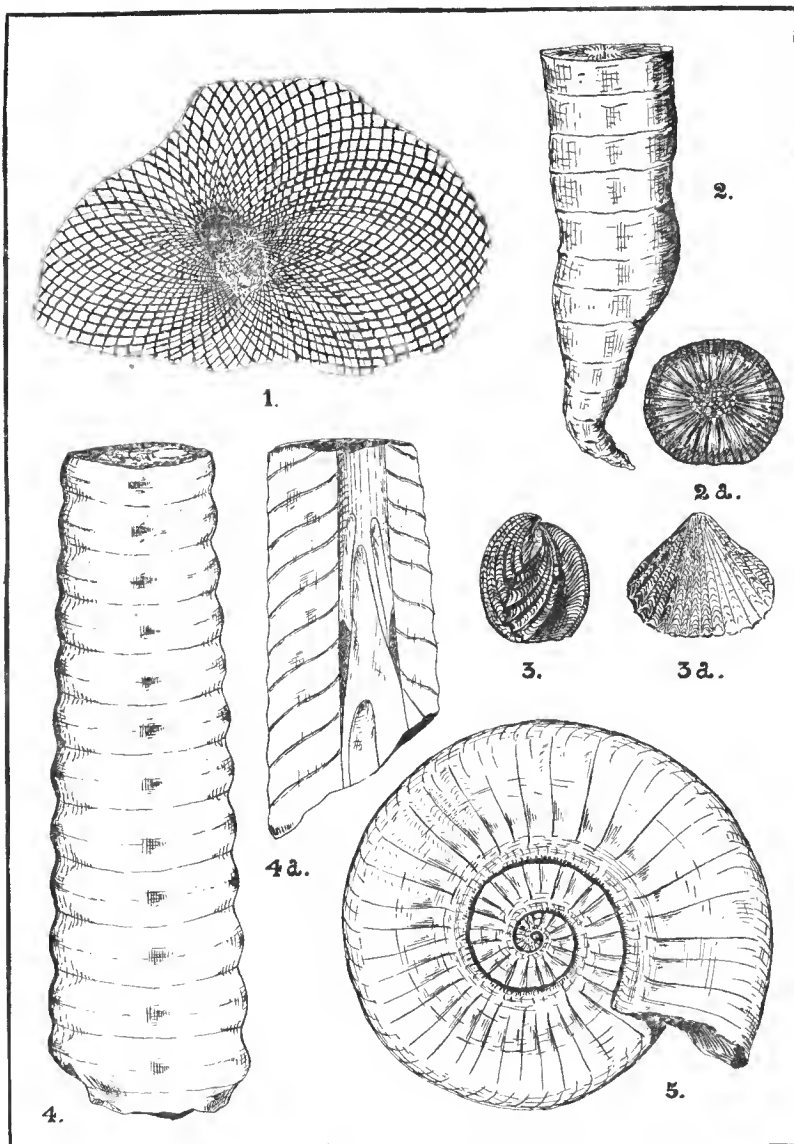


PLATE IV

Ordovician Fossils in Manitoba

1. *Receptaculites oweni*. (Hall). (Copied after Schuchert and Winchell).
2. *Streptelasina rusticum*. (Billings). (Copied from drawing by Lambe).
- 2a. *S. Rusticum*. Top view. (Copied from drawing by Lambe).
3. *Rhynchotrema capax*. (Contod). (Side view). (Copied from Coleman and Park's General Geology).
- 3a. *R. capax*. Dorsal view. (Copied from Coleman and Park's General Geology).
4. *Endoceras annulatum*. (Hall). (Copied from drawing by Hall).
- 4a. *Endoceras annulatum*. (Hall). Showing the inner structure. (Copied from drawing by Hall).
5. *Maclurea manitobensis*. (Whiteaves). View of specimen from convex side. (Copied from Whiteaves).

beds specimens of *Favosites aspera* are found. The yellow argillaceous beds hold many casts of brachiopods; but the beds rich in fossils are the underlying red shales. Bryozoa, corals, brachiopods and gastropods are the most numerous, and are very well preserved. Sixty-one species have been identified from the Stony Mountain formation, over 50 of them from the red shales. Among the commonest species are *Streptelasma rusticum*, *Streptelasma trilobatum*, *Dinorthis subquadata*, *Rhynchotrema capax*, *Pleurotomaria bicincta*, and numerous species of Bryozoa

Ordovician rocks are exposed in the Lake St. Martin area, in the Grass river valley as a scarp on the PreCambrian surface, and on the lower reaches of the Nelson and Shammattawa rivers. They have not been subdivided as in the lake Winnipeg area. Savage and Van Tuyl have made a detailed study of the fauna of the Nelson and Shammattawa river exposures. On the Nelson river, the Nelson river limestone, with a thickness of 60 feet, is exposed at or above the Upper Limestone rapids. It is a grey mottled limestone, with a fauna closely resembling that of the Upper Mottled limestone. It is overlaid (with an eastward dip) by the Shammattawa limestone (47 feet) at or immediately above the Lower Limestone rapids, which beds are also exposed for 15 miles on the Shammattawa river (38 feet), with a rich fauna closely resembling that of the Stony Mountain beds. The similarity of fauna in the two areas is so marked as to indicate that there was continuous sea from Hudson bay to southern Manitoba, and probably to Wyoming and Colorado, from Trenton times to at least the close of the Ordovician period.

From the economic standpoint, the important formation is the Upper Mottled limestone, which first at Lower Fort Garry, later at East Selkirk, and now at Garson (Tyndall) has supplied a building stone which has been used in many of the large public buildings in Winnipeg and other western cities. The Legislative Buildings in Winnipeg are built of this stone, and the interior finish of the Parliament Buildings in Ottawa is of the same material. The Lower Mottled limestone from Big island has been used for rubble, the quarry beds at Stony mountain are used for the same purpose. The pure sand of the Winnipeg sandstone at Black island and Elk island is well adapted for glass making, and may yet be used for that purpose.

(b). *The Silurian Period.*

Rocks of Silurian age are exposed between lake Winnipeg and lake Manitoba, along the Saskatchewan river from Grand Rapids westward to Cumberland lake, and on the Nelson river. The rocks are dolomites, with a gypsum horizon between the lower and upper dolomites. Deposition took place under shallow water conditions, and the fauna obtained from Silurian rocks in the southern area is much less varied and abundant than that from the Ordovician rocks. The best exposures are at the quarries at Stonewall, Gunton and Inwood, at Grand Rapids on the Saskatchewan river, at Cedar

lake and Moose lake, and on the northeast end of Lake Manitoba. Rocks of this age also show on the lower Nelson river.

Kindle worked out the following stratigraphical succession for the exposures from the Saskatchewan river southwards. The estimated thicknesses are by the writer.

Stonewall series—

Leperditia hisingeri zone, 100 feet.

Gypsum beds, 150 feet

Conchidium decussatum zone, 135 feet.

Conchidium Decussatum Zone.

The strata of the Conchidium decussatum zone (which Savage and Van Tuyl have shown should be renamed the Virgiana decussata zone), are found in the southern part of the province at Stonewall, Gunton, at Fisher Branch and at Grand Rapids on the Saskatchewan river. They have not been found resting directly on the Stony Mountain formation, but at Stonewall a cross-bedded sandstone succeeded by a red clay at the base of the quarries is probably the transition series from the Ordovician to the Silurian systems. The quarry beds consist of a harsh dolomite, buff to grey in colour, pitted on account of the dissolving of fossils, mainly Favosites sp., but not rich in good fossil material. The Virgiana band is not found at Stonewall or Gunton (Tyrrell, however, records the occurrence of Conchidium decussatum from Stonewall,) but is found northwest of Fisher Branch, and at Grand Rapids. There is a thickness of at least 65 feet below the Virgiana decussata line in the Silurian of the Stonewall and Gunton exposures, and the total thickness of the zone from the base at Stonewall to the top of the Grand Rapids beds is approximately 135 feet. The part of the zone below the Virgiana decussata line is considered by Savage to be pre-Niagaran in age. The following are some of the fossils from this zone: Aphyllostylus gracilis, Favosites gothlandicus, Favosites asper, Virgiana decussata, Spyroceras meridionale, Trochoceras insigne.

Gypsum Beds.

The gypsum beds are exposed and are quarried at Gypsumville, northwest of lake St. Martin. They are also found near the surface at Leifur, west of the south end of lake Manitoba, and have been found by drilling at Ashern, Rathwell, Arnaud, St. Elizabeth, St. Charles and Dominion City. Their stratigraphical position, in the Gypsumville exposure, is placed on somewhat limited evidence, as they lie on or near the PreCambrian outlier, with little limestone associated with the beds, and are apparently very limited in distribution in that particular area. Their probable position is immediately above the Virgiana decussata zone and below the Leperditia hisingeri zone which is found south and west of the gypsum exposures. By drilling, a total thickness of 150 feet of gypsum and anhydrite has been found at Gypsumville, of which the top 20 feet are quarry beds. There is a gradual change from gypsum to

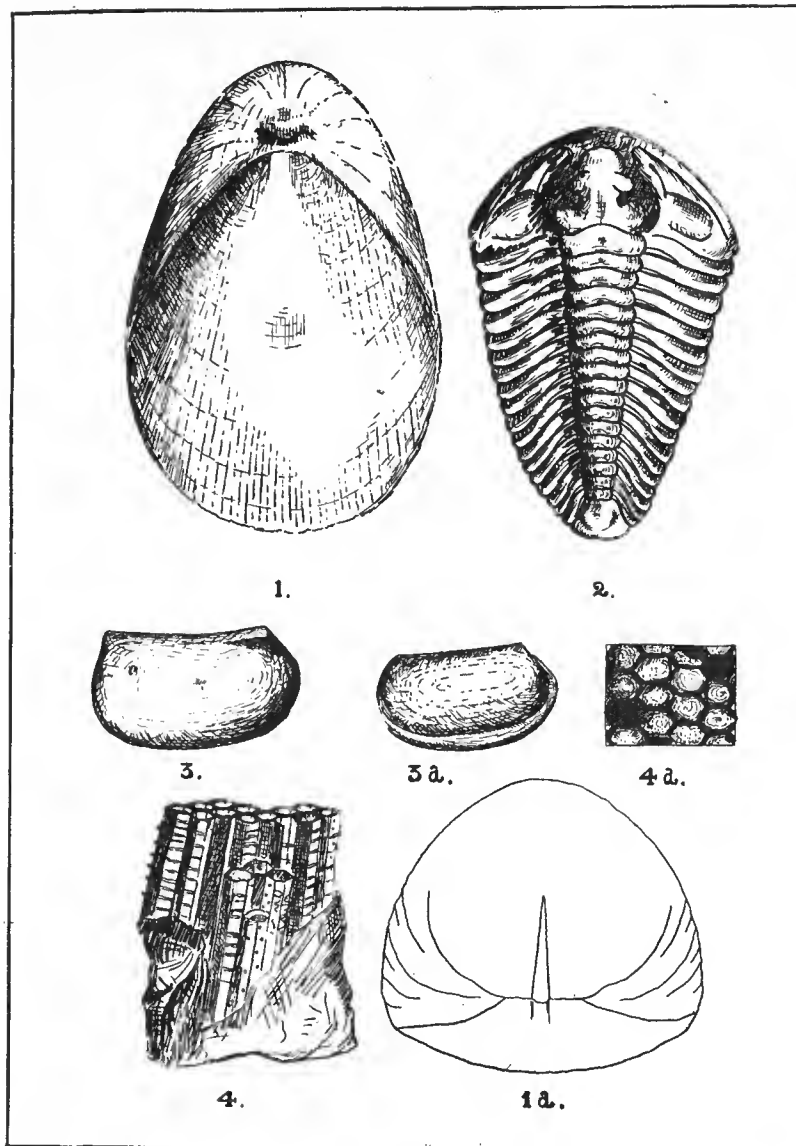


PLATE V

Silurian Fossils in Manitoba

1. *Conchidium decussatum*. (Whiteaves). (*Virgiana decussata*). Dorsal view. (Copied from drawing by L. M. Lambe).
- 1a. *Conchidium decussatum*. (Whiteaves). (*Virgiana decussata*). Outline of the posterior end of a cast of the interior of bot valves. (Copied from drawing by L. M. Lambe).
2. *Calymene niagerensis*. (Hall). (Copied from drawing by Hall).
- 3, 3a. *Leperditia hisingeri*. (Schmidt). (Copied from drawing in Von Zittel's *Palaeontology*).
4. *Favosites asper*. (D'Orbigny).
- 4a. *Favosites asper*. (D'Orbigny). View of colony from the top.

anhydrite with depth, and the gypsum has been derived, in part at least, from original anhydrite. The symmetrical folds which characterise the gypsum of the quarry beds appear to be caused by the expansion which accompanied the change of anhydrite into gypsum.

The conditions which gave rise to the deposition of anhydrite and gypsum in this area are not as yet fully elucidated. In the Gypsumville district it seems not improbable that the PreCambrian outlier had something to do with the isolating of a small deposition basin in the stage of shallowing of the Silurian seas; with the result that sulphates of lime were deposited in that district at the same time as dolomites may have been deposited elsewhere. Fuller drill records from Dominion City in particular would be of material assistance in establishing definitely the stratigraphical succession. In all the localities where gypsum has been found, it rests on red clays of considerable thickness. At Dominion City a thickness of 60 feet of gypsum was reported, underlain by 110 feet of red clay and sand. At Arnaud the gypsum is 25 feet thick, and the red clay 135 feet thick. At Gypsumville the thickness of the basal red clays has not been ascertained by drilling.

Leperditia Hisingeri Zone

The *Leperditia hisingeri* zone consists of fine-grained dolomites, almost lithographic in fineness. They are exposed at Inwood, Broad Valley, on the Canadian National railway from Camper northwards to Old Gypsumville, on the east side of Waterhen lake, on lake Winnipegosis from Hill island northwards to Ami island, on Gross lake, Cedar lake and at Grand Rapids. On the lithographic dolomites rest deep red argillaceous dolomites on which the basal limestones of Devonian age in turn rest. In the Ashern district the *Leperditia hisingeri* zone does not exceed 100 feet in thickness. Tyrrell describes a section from Roche Rouge westwards on the Saskatchewan river which is probably considerably thicker. There is a striking resemblance between the lithographic dolomite of this zone and the Gower dolomite of the Niagara in Iowa in purity, fineness of grain, thin-bedding, cross-bedding, and association with chert. The rock is not very fossiliferous, but certain beds are crowded with ostracod shells, mainly *Leperditia hisingeri*. Other fossils are *Favosites favosus*, *Glassia variabilis*, *Stropheodonta acanthoptera*, *Orthis flabellitis*, and several stromatoporoids.

In the Hudson bay region, the Silurian rocks are exposed in Manitoba only on the Nelson river. The exposures are four miles below the Lower Limestone Rapids, and the 28 feet of yellowish dolomite there exposed have been named by Savage and Van Tuyl the Port Nelson limestone, representing, in the Hudson bay area, the Silurian beds up to, and including, the *Virgiana decussata* line. It corresponds approximately to the Stonewall, Gunton and Fisher Branch exposures in southern Manitoba. From the fuller evidence on the Severn and Winisk rivers, it would appear that a continuous

sea extended from Hudson bay to southern Manitoba in early Silurian times.

The important beds from the economic standpoint are the gypsum beds. The lower dolomites of the Stonewall series are used for lime manufacture at Stonewall and Gunton, a very white slow-slaking lime is obtained. The dolomite of the Broad Valley exposure (*Leperditia hisingeri* zone) which is of almost lithographic fineness, may yet find a market for interior decorative purposes. The gypsum beds at Gypsumville have been mined for over 20 years, and the industry supplies the needs of the prairie provinces. The raw material is shipped by railway car to Winnipeg, and there calcined and manufactured into building products. The raw material is used in the manufacture of Portland cement.

(c). *The Devonian Period.*

Rocks of Devonian age are found exposed on lake Manitoba are lake Winnipegosis, Waterhen lake, lake Dauphin, Swan lake, Red Deer lake, and in the immediately surrounding territory. They were classified by Tyrrell, who did the first detailed work on this system in Manitoba, as follows:

Manitoba limestone.
Winnipegosis dolomite
Red shales.

The Red shales placed by Tyrrell at the base of the Devonian, have been relegated to the base of the Winnipegosis dolomite. The following classification has been given by Kindle:

Manitoba limestone, 185 feet.
Winnipegosis dolomite, 168 feet
Elm Point limestone, 25 feet.

Elm Point Limestone.

In the Elm Point limestone Kindle placed two exposures—that two miles north of Oak Point, and those on the shore of Lake Manitoba immediately north of Elm Point. The following localities may be added to those given by Kindle: Bannock hill, south of Ashern; quarry northeast of Moosehorn; island at north end of Waterhen lake; point Brabant and Graves point, lake Winnipegosis. The rock is a non-magnesian limestone, with argillaceous phases, and arenaceous in its upper beds. The colour is light grey to dark brown, and shows in the Steep Rock quarry and elsewhere a very striking mottling with pebble-like masses of the dark brown rock in the light grey limestone. This is probably due to partial dolomitisation. Stylolitic flutings and pittings are very common. A very characteristic feature is the occurrence of thin beds packed with shells of *Atrypa reticularis* with peculiar marginal extensions (var. a of Kindle). In addition to this type fossil, the following are common in this formation: *Atrypa spinosa*, *Productella spinulicosta*, *Paracyclas elliptica*, var *occidentalis*, *Euomphalus subtriangularis*, *Loxonema antivolvus*, *Loxonema cingulata*.

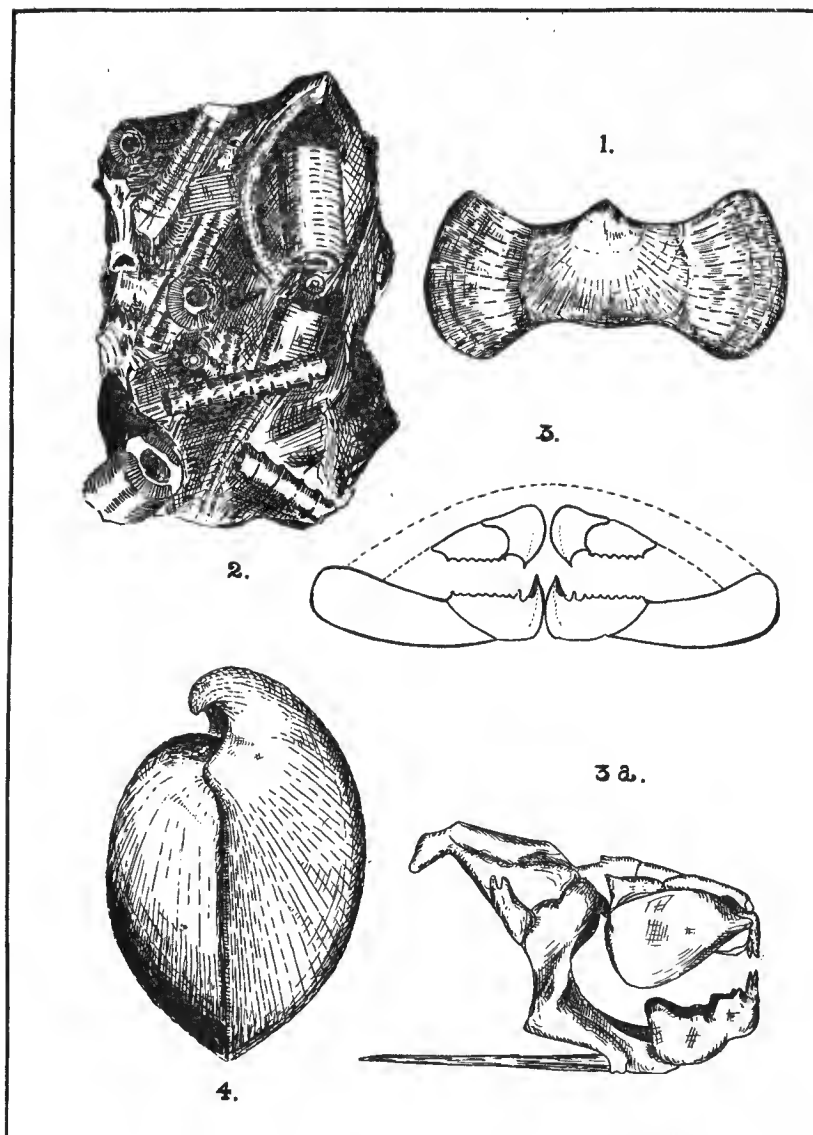


PLATE VI

Devonian Fossils in Manitoba

1. *Atrypa reticularis*. (Linnaeus). Var. A showing wing-like projections.
2. Crinoid stems in Winnipegosan Dolomite. Chiefly *Ctenocrinus* sp.
3. *Dinichthys hertzeri*. Jaws, copied from drawing by Newberry.
- 3a. *Dinichthys hertzeri*. Skull. Drawing copied from figure in Graban and Schuchert's *Geology*. (This species has not been found in Manitoba but *D. Canadensis* has been reported).
4. *Stringocephalus burtoni*. (Defr.) Side view. After Von Zittel.

Winnipegosan Dolomite.

The Winnipegosan dolomite is best exposed on Whiteaves point in Dawson bay, lake Winnipegosis, and on the island northwest from that point. It is found also at Salt point, and the point west of Rowan island, Dawson bay, Hill island, Pemmican island and near Devil's point, lake Winnipegosis, and on the islands in Totes Aides bay, lake Manitoba. The rock is a harsh porous dolomite of light grey or cream colour, exceedingly hard and tough, full of fossils which are very difficult to break out from the rock. At its base is a red shale, seen by Tyrrell on Pemmican island, and found by the writer near Devil's point. A red argillaceous dolomite or shale also caps this zone, and marks the transition to the Manitoba limestone. The characteristic fossil of the zone is *Stringocephalus burtoni*, which has a wide geographical range north-westwards through the Mackenzie basin, across to Asia and eastern Russia. Crioid stems are very plentiful in this dolomite. The following are some of the commonest fossils: *Cystodictia hamiltonensis*, *Atrypa reticularis*, *Atrypa spinosa*, *Stringocephalus burtoni*, *Productella spinulicosta*, *Glossites manitobensis*, *Proetus mundulus*.

Manitoba Limestone.

The Manitoba limestone is exposed on lake Winnipegosis at Snake island and southwest of Charlie island, at the mouth of Mossy river, on the west side of Pelican bay, on the west side of Swan lake (south of Swan river), on Dawson bay between the mouth of Bell river and Salt point peninsula, on Red Deer river, and on the south shore of Red Deer lake. It is exposed also at several of the salt springs which are found near the west shore of lake Winnipegosis. Lithologically, the rock is very similar to the Elm Point limestone, and the two horizons cannot be distinguished in the field on purely lithological grounds. The colour is greyish brown, the rock is very friable, and the fossils are extracted readily. Heavy beds are seldom seen. The mottling which was noticed in the Elm Point limestone in some localities is not in evidence in the Manitoban limestone; but stylolitic markings are very common in both formations. At the base of the formation is found, in anticlinal folds east of Bell river, Dawson bay, an argillaceous limestone at least 21 feet thick. The top of the formation is seen on the south shore of Red Deer lake as an unfossiliferous sandstone with an exposed thickness of 1½ feet. It is probably this sandstone which appears as inclusions in the brecciated beds at the top of the point Wilkins section.

The commonest fossil in this, as in other horizons of the Devonian in Manitoba, is the brachiopod *Atrypa reticularis*, here without the peculiar flange shown in the Elm Point limestone beds. Kindle has divided the Manitoba limestone formation into two zones:

- (b) *Athyris fultonensis* zone.
- (a) *Cyrtina hamiltonensis* zone.

the upper zone including the upper 45 feet of the Point Wilkins beds, the Swan Lake limestone, and the rock exposed on Red Deer lake and Red Deer river above Pelican rapids. In lower horizons *Athyris fultonensis*, which is abundant in these beds, is not found; while *Cyrtina hamiltonensis*, found in the lower beds, is not found in the upper zone. The following are some of the characteristic fossils of the Manitoban limestone: *Astraeospongia hamiltonensis*, *Alveolites vallorum*, *Atrypa reticularis*, *Atrypa aspera*, *Reticularia richardsoni*, *Cyrtina hamiltonensis*, *Paracyclas elliptica*, *Raphistoma tyrrelli*, *Dinichthys canadensis*

The thicknesses of the Elm Point limestone and the Winnipegosis dolomite are given as estimated by Kindle. The estimated thickness of the Manitoban limestone as calculated by the writer, is based on the drill hole sections southeast of Charlie island, the Snake island beds and the Point Wilkins section.

A structural feature of interest in the Devonian exposures is the occurrence of numerous domes in all the Devonian horizons. In some cases there is a definite axis of folding, and the structural feature is a swollen anticline rather than a dome. In most cases the elevation has taken place from a central point. East of the mouth of the Bell river, the width of an exposed fold is 100 yards, and the height of the section at the central part of the fold is 26 feet. Such domes or folds are responsible for nearly all the exposures of Devonian rock on lake Manitoba or lake Winnipegosis. There is no evidence that they are coral reef or stromatoporoid reef domes; and an adequate explanation of this structural feature, peculiar to Devonian strata in Manitoba, is not yet forthcoming.

From the economic standpoint, the Elm Point and Manitoban limestone are, in certain beds, very pure non-magnesian limestones, and are available for Portland cement manufacture or for the pulp industry. The quarry at Steep rock supplies limestone to the Canada Cement Company's mill at Winnipeg. The Point Wilkins beds are of the same quality of limestone, but have not yet been used for cement purposes. Numerous salt springs issue from the Winnipegosis dolomite and the Manitoban limestones on the west side of lake Winnipegosis and lake Manitoba. They are a weak brine, and are probably formed from solution of salt crystals in the Winnipegosis dolomite by water circulating from the Dakota sandstone horizon. For many years—from 1800 to 1875—the salt used at the Hudson's Bay Company posts and at the Red river settlement was obtained by evaporating these brines in iron troughs or kettles.

Life of Palaeozoic Times.

In reviewing the life of Palaeozoic times, as indicated by the fossil evidence from the horizons of Manitoba, it will be noted that during the period of deposition from early Ordovician times to middle Silurian times the invertebrate fauna consisted in the earlier stages of large cephalopods, gastropods, cup corals and sponges, with abundant brachiopods, colonies of compound corals and

bryozoa. In the later stage of this period of deposition compound corals assumed greater relative importance, and the cephalopods diminished in numbers. Shallower water conditions intervened, gypsum was deposited in inland basins, and the period closed with shallow seas in which ostracods, brachiopods and stromatoporoids were the dominant forms of marine invertebrate life. The second period extends from early middle Devonian to late upper Devonian times. The marine life during this period consisted mainly of brachiopods, compound corals, crinoids, sponges and cephalopods, with brachiopods dominant. Spines of fishes are numerous in the upper beds, and this first order of vertebrates may have come in with the earliest Devonian seas in this area. The rocks are not well adapted for the preservation of fish fossils, and no good specimens have been obtained.

Of plant remains nothing but fucoidal traces—somewhat indefinite except in the Cat Head limestone, in which excellent specimens have been obtained—has been found in the Palaeozoic strata of Manitoba. Of the abundant vegetation that flourished elsewhere during Carboniferous and Permian times, and of the amphibians which were the dominant vertebrates of those periods, no trace has been found in Manitoba. It would appear that the area under discussion was so extensively elevated after Devonian times that swamp conditions nowhere prevailed during the Carboniferous period. Such forests as may have flourished passed away without leaving any trace behind.

IV THE MESOZOIC ERA

Cretaceous Period.

The continental conditions which were initiated with the elevation at the close of Devonian times, were maintained throughout the remainder of the Palaeozoic era, and during the first two periods (Triassic and Jurassic) of the Mesozoic era as well. Not until upper Cretaceous times did the seas again invade the territory that is now Manitoba. There is therefore a gap of very long duration in the rock sequence, and the basal sandstones of Cretaceous age rest directly on the Upper Devonian limestones. To represent the intervening time, nothing has been left in the territory under discussion.

The Cretaceous beds, which are exposed in the southwestern part of the province, and of which the hills of the Manitoba escarpment—Pembina hills, Tiger hills, Riding mountain, Duck mountain, Porcupine mountain and Pasquia hills—are built up, have been subdivided by Tyrrell as follows:

Pierre	{	Odanah series,	400 feet
Shales	{	Millwood series,	650 feet
Niobrara shales,			250 feet
Benton shales,			178 feet
Dakota sandstone,			200 feet

Dakota Sandstone.

The Dakota sandstone is exposed on the banks of the Red Deer, Armitt, Kamatch, Swan and Carrot rivers, and at Kettle hill on Swan lake. It was laid down on the eroded and irregular floor of the Devonian rocks (Manitoban limestone), and its thickness therefore varies to a very marked degree. The figure given above is probably the upper limit of thickness of this formation. It consists of white or reddish sand grading up into green sandstone and shale, the lower sands being in several exposures quite unconsolidated. The sandstone may weather, as on Kettle hill, Swan lake, into rounded boulder-like masses. It is not markedly fossiliferous, but contains impressions of coniferous leaves, fragments of wood, and the following fauna: *Lingula subspatula*, *Ostrea congesta*, *Modiola tenuisculpta*, and scales of fishes. This is an important water-bearing horizon, with considerable circulation, and not favourable for the preservation of fossils.

Benton Shale.

The Benton shale is very carbonaceous, dark grey in colour breaking down readily into thin flakes like graphite, and unctuous to the feel. A section is exposed on Rolling river, a tributary of Swan river, on the north slope of Duck mountain, and again on Kamatch river, Porcupine mountain; and on Old Man river, Pasquia hills. From a drill record on Vermilion river (Riding mountain) the thickness of the Benton formation was estimated to be 178 feet. The formation probably thins towards the north. These shales are poor in fossils. Fragments of *Ostrea* and *Inoceramus* have been recorded.

Niobrara Shales.

The Niobrara shales, unlike the Benton shales, are shown in many exposures in the Manitoba escarpment, more particularly in the river cuts on the north slopes of the Riding and Porcupine mountain, on Swan river and Assiniboine river. The beds consist of calcareous shale, with a solid ledge of limestone near the top of the formation, serving as a fairly definite horizon marker over the whole of the Manitoba escarpment. Owing to their hard nature, the beds are exposed in sharper cliffs than the underlying Benton shales, which are usually concealed. An interesting feature in connection with the Niobrara horizon is the abundance of Foraminifera in the rock, giving the grey shale a somewhat speckled aspect. The commonest species is *Globigerina cretacea*, but *Globigerina bulloides*, *Globigerina limnaena*, *Textularia globulosa* and several other species have been identified. The beds have a chalky aspect where the foraminifera are most numerous. In the limestone band the following are the commonest fossils: *Ostrea congesta*, *Inoceramus problematicus*, *Belemnitella Manitobensis*, *Anomia obliqua*. This band is found as far north as Old Man river on the west side of Pasquia hills and serves as an index bed in the Cretaceous exposures from south to north. It represents the only limestone horizon in Manitoba later than Devonian times.

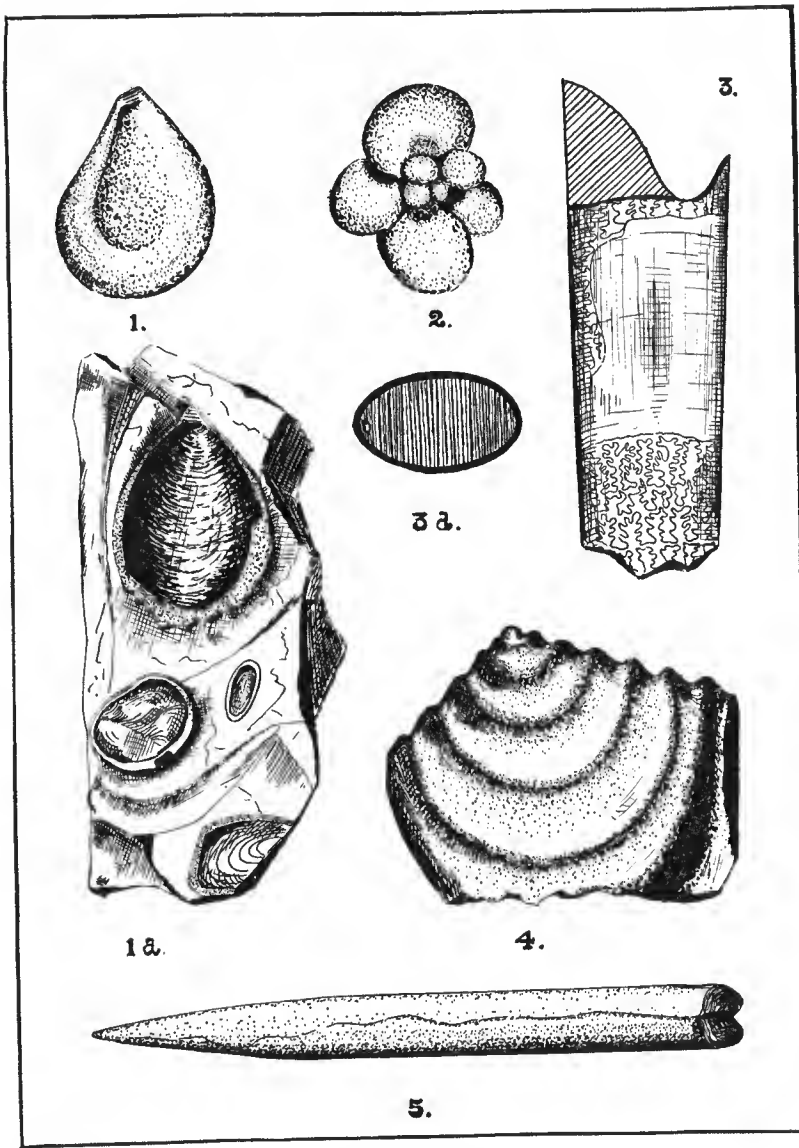


PLATE VII

Cretaceous Fossils in Manitoba

11. *Ostrea congesta*. (Conrad). Interior of upper valve. Copied from drawing by Stanton.
- 1a. *Ostrea congesta*. (Conrad). Group of attached lower valves. Copied from drawing by Stanton.
2. *Globogerina bulloides*. (D'Orbigny). Minn. Geol. Surv.
3. *Baculites compressus*. (Say). Side view, copied after Meek.
- 3a. *Baculites compressus*. (Say). Cross Section, copied from drawing after Meek.
4. *Inoceramus sagensis*, var. *Nebrascensis*. (Owen).
5. *Belemnites* sp.

Pierre Shales.

The Pierre shales form the uppermost beds in the Manitoba escarpment (with the exception of glacial clays) in Pembina hills, Tiger hills, Riding mountain, Duck mountain, Procupine mountain and Pasquia hills. They have been subdivided by Tyrrell into the Millwood (lower) and Odanah (upper) series. The Millwood shales are dark grey soft clay shales, exposed in the Assiniboine valley from Fort Pelly southward, at Minnedosa, on the Ochre and Vermilion rivers, on North Pine and Bell rivers. They are not highly fossiliferous, but from an exposure on Bell river 16 species of Radiolaria were determined; also at Millwood a fauna of which the following is a partial list: *Pteria linguiformia*, *Inoceramus tenuilineatus*, *Lucina occidentalis*, *Baculites compressus*, *Scaphites nodusus*. These were obtained from ironstone nodules which occur plentifully in bands in the Millwood shales. The Odanah shales are light grey in colour and break down into lenticular pebbles. They are found in the valley of the Assiniboine river, on the Little Saskatchewan river at Odanah near Minnedosa, on Vermilion river, on Old Man river in Pasquia hills, and at La Riviere on Pembina hills. Hind found the following fossils from this series in an exposure on the Assiniboine river near the mouth of Two Creeks: *Anomia flemingi*, *Inoceramus canadensis*, *Yoldia hindi*, *Lunatia obliquata*, *Cinulea concinna*, *Ammonites* sp. Fossils are, however, rare in these shales.

The Cretaceous exposures in Southern Manitoba, from Pembina mountain westwards, have been worked out by Maclean. He has estimated the thickness of the Niobrara beds, as exposed, at 391 feet, and of the Millwood beds at 130 feet. A 3-8 foot bed of limestone is placed by him at the base of the exposed Niobrara section. This seems to be the same bed as that placed by Tyrrell near the top of the horizon. It is exposed on the Assiniboine river, and is found by drilling at a depth of 28-55 feet below the surface at Morden. The upper 50 feet of the Millwood series consist of waxy clay, probably colloidal. The Odanah series has a total thickness of at least 250 feet in this southern area; but the highest beds may have been eroded, as the glacial drift rests directly on the Odanah series. In this area the main exposures of Odanah series are on Dead Horse creek, Pembina river, Assiniboine river and Souris river. From drill records they are apparently overlaid by colloidal clay in the southwest corner of the province.

Indications of oil are found throughout the Manitoba escarpment in the Benton, and particularly in the Niobrara shales. The values are too low (8-10 gallons per ton) for successful distillation, and, though drilling has been done in several localities, no reservoirs of oil have been found. Small reservoirs of gas have been tapped in several places, and use has been made of the gas locally. An outcrop of marl in the Niobrara series at Babcock has been mined for several years for the manufacture of natural cement. Shale horizons in the Niobrara beds at Leary's west of Carman, and

in the Odanah series at La Riviere have been used for the manufacture of brick; and experiments have been made in mixing shale from the Niobrara and Odanah horizons for brick, hollow tile, and sewer piping, the purpose of the mixing being to reduce the high shrinkage on drying, and to modify the effect of the carbonaceous constituent of the Niobrara shales.

Life of Mesozoic Times.

In reviewing the life of Mesozoic times in Manitoba, the Cretaceous formations, which are all marine, give evidence of a somewhat limited distribution of lamellibranchs, cephalopods and fishes. The muddy seas were not favourable to marine life. It is all the more interesting that there should be found in shales of Niobrara and Millwood age abundant Protozoa (Foraminifera and Radiolaria respectively) such as are usually held to inhabit fairly deep clear seas. Of the reptilian life of Mesozoic times so abundant in the Cretaceous of Alberta, no trace has yet been found in the Mesozoic beds of Manitoba. There are found in the Dakota sandstone pieces of wood and impressions of leaves, an evidence of coniferous forests in the near vicinity to the advancing sea in which the sandstones were being deposited.

V. THE CAINOZOIC ERA

a. Tertiary Period.

No detailed examination has yet been made of rocks of Tertiary age in Manitoba. They are known to occur in Turtle mountain in southwestern Manitoba, and they may possibly occur as well at the top of the Riding, Duck or Porcupine mountains; but rock exposures are concealed under a drift mantle. In Turtle mountain there is a thickness of at least 800 feet of Tertiary strata above the sandstone which outcrops immediately south of Boissevain, and which is presumably of Fox Hill sandstone age, formerly placed with the Tertiary, now more frequently placed at the top of the Cretaceous. This sandstone is a friable, diagonally bedded rock, which hardens on exposure, and has been used as a building stone in Boissevain. Above the sandstone are shales, clays and sands, with seams of coal which are found outcropping mainly on the northwest and northeast shoulders of the mountain. These seams are found principally in the strata within 200 feet vertically above the top of the sandstone. Their outcrop and probably extension have been mapped by Dowling. The rock outcrops are very limited and little is known of the nature of the beds. They are probably of freshwater deposition, as some freshwater shells have been found, and they are associated with coal beds not only at the base, but in a well-excavation near the top of the mountain as well. From what is known of the Estevan field in southeastern Saskatchewan, and of the strata exposed to the south in North Dakota, the upper beds in Turtle mountain probably belong to the Fort Union formation of Eocene age. No later Tertiary deposits have been found

During Oligocene, Miocene and Pliocene times it would seem that no deposition took place in Manitoba territory.

Dowling has estimated 160 million tons of coal in this area. It is a soft lignite, and has not yet been mined in quantity. For several years farmers in the vicinity of outcrops dug out coal from exposed seams for their own, or purely local, use. The seams vary in thickness up to 7 feet, but are usually much thinner, and are discontinuous in lateral extension. A borehole was put down by Dr. Selwyn at a point well up the mountain (Sect. 5, Tp. 2, Rg. 19) to 200 feet, but encountered no coal, and probably passed through a pocket of Pleistocene deposits.

b. Quarternary Period.

The Quaternary Period is divided into two subperiods (i) *Pleistocene* (Great Ice Age) and (ii) *Recent*.

(i) The Pleistocene is represented in Manitoba in all parts of the province. The icesheets which moved southwards over the province left deposits in the form of sheets of till, moraine ridges and drumlins, eskers and outwash gravel fans and erratics, while the lakes which were impounded in front of the ice formed beaches and delta deposits, and were responsible for the sedimentation of finely laminated clays and silts. The glacial deposits form a thin covering on the surface of the rock formations that would otherwise be exposed, and vary in depth from a few inches to over 200 feet, the latter very exceptionally. The hard rocks on which they rest have been smoothed and polished, and frequently striated, by the icesheet as it moved forward. The rock surfaces now exposed in PreCambrian areas in particular show the hummocky form, especially when viewed from the north, which is characteristic of glaciated country. The general movement of the ice was from the north-east southwestwards, though west of lake Winnipeg, in the southern part of the province, a southward or even southeastward movement of the ice may also be noted from the striations on the rock surfaces.

Johnston has described a till in the Whitemouth lake area which was probably deposited by the southeastward moving ice, and considers that this till has resulted from a later movement than the southwestward moving sheet, and may be due to deflection of the ice by the Manitoba escarpment. The numerous boulder islands (drumlins) on lake Winnipeg, together with some evidence of pre-glacial weathered surface on Deer island (vide Wright) might indicate that lake Winnipeg, in the later stage of the movement at least, lay in the line between the two sheets of ice. The gathering ground of the ice which passed over Manitoba lay mainly west of Hudson bay. Tyrrell has placed the centre of this—the Keewatin—ice sheet in the vicinity of latitude 62°. After this sheet began to withdraw, according to Tyrrell, ice moved northwards, probably westwards and southwards from a gathering ground between Hudson bay and lake Superior—the Patrician centre. Still later the Labradorian icesheet came southwestwards; but to what extent the latter two icesheets affected the southern part of

Manitoba is not yet known. That the Labradorian icesheet moved southwest over the south end of Hudson bay is shown by the till containing marine shells which is exposed on the banks of the rivers flowing northeastward into Hudson bay. Tyrrell has found evidence on the lower reaches of the Hayes river which might be interpreted as indicating the western limit of the Labradorian icesheet in that area.

Two sheets of till have been recorded on the Hayes river and on the Shammattawa river; and two sheets are considered by Johnston probably to occur in southeastern Manitoba. Little evidence has been obtained of interglacial conditions from the beds which lie between the sheets of till. No fossils have been found on the Hayes river. Tyrrell records moss and wood between the tills on the Shammattawa river. On the Rolling river, on the north side of Porcupine mountain, in sands underneath the till, considered to be interglacial, Tyrrell found the following:

Diatomaceae *Navicula lata*, *Encyonema prostratum*, *Denticula lauta*, *Licmophora* (?), *Loccineis*.

Phanerogama: *Taxus baccata*, seeds of a conifer, *Elodea canadensis* (?), *Vallisneria* (?).

Mollusca *Limnaea catascopium* (?), *Valvata tricarinata*, *Amnicola porata* (?), *Planorbis bicarinatus*, *Planorbis parvus* (?), *Pisidium abditum*, *Sphaerium striatinum*.

Moraines, outwash deposits and eskers were left by the retreating icesheet, and form topographical features of importance. These have been mapped by Upham in the southern part of the province. The most important moraine is that which extends northwards from North Dakota into Manitoba through Rock lake, east of Pelican lake, thence northwestwards through the west end of the Tiger hills to the Brandon hills; and continuing again across the Assiniboine river as the Arrow hills northwestwards parallel to the river. This (Itasca) moraine was the eastern rim of glacial lake Souris, which emptied at first southwards through the Sheyenne river, then through the Pembina river by way of Lang's valley, and later by the Souris river northwards to the Assiniboine river. As the ice receded another important moraine (the Mesabi moraine) was deposited on the eastern flank of the Pembina hills, northwards to the east end of the Tiger hills, is broken by the Assiniboine delta of lake Agassiz, and extends northwestwards through Basswood to the Riding mountains. This represents the western margin of glacial lake Agassiz. East of the Red river, from South Junction northwards, through Sandilands, morainic deposits have been mapped by Johnston, and were apparently deposited in irregular fashion by icesheets advancing from the northeast and the northwest. Many other morainic deposits are known in the province, but have not yet been systematically mapped.

Fluvioglacial sand and gravel deposits (eskers) formed by the subglacial rivers as they emerged from the icesheet, are illustrated by Birds' hill, northeast of Winnipeg, by Burns ridge, northwest

of Grosse Isle, and in isolated hills and irregular ridges. They show diagonal bedding, rapid change from sand to gravel, and other indications of a torrential river action. They were probably gradually submerged under lake Agassiz as the ice underneath the sand and gravel disappeared.

The icesheet blocked the northward drainage, and glacial lakes—lake Saskatchewan, lake Souris and lake Agassiz—were formed. Lake Saskatchewan (extending northwards from the elbow of the South Saskatchewan river) drained south into lake Souris through the Qu'Appelle valley, forming a delta which is now seen as the sand hills from Griswold northwestwards. The drainage of lake Souris has already been referred to. Lake Agassiz, the greatest of the glacial lakes of the continent, had as its western boundary the Manitoba escarpment (Pasquia hills, Porcupine, Duck and Riding mountains, Tiger hills, Pembina hills). In Manitoba, North Dakota and Minnesota the extent of the lacustrine area of lake Agassiz was over 110,000 square miles. At the maximum development of the lake it occupied probably three quarters of this area, but was blocked by ice towards the north from ground which at lower stages was under the lake. In successive stages the lake was drained, first southwards to Minnesota river and the Gulf of Mexico, and later northwards to Hudson bay. The southward channel is well seen in the lake Traverse Big Stone lake valley. The northward channel was probably at first by the Hayes river, the valley of which river bears evidence of much older and more extensive erosion than that shown in the Nelson river valley. The level of the lake was maintained sufficiently long at each stage to permit of the accumulation of beaches, which are very distinctly tracable, particularly on the western margin of the lake. Twenty-seven of these beaches have been mapped by Upham, of which eighteen were formed when the lake emptied southward, and nine after the northern outlet had been opened. The highest is the Herman beach, at an elevation of 1205 feet at the International boundary, and 1305 feet at Neepawa. Owing to a differential elevation towards the north as the icesheet disappeared, the earlier beaches rise about one foot a mile as one proceeds northwards. The depth of the site of Winnipeg at this earliest stage would have been over 500 feet below the surface of the lake. Fourteen beaches are seen in the railway section from Thornhill to Morden. East of the Riding mountain the beaches are again well shown, the Upper Campbell beach at Arden and northwards (Beautiful Plain) being particularly prominent. The lowest beach on the west side of lake Winnipeg is approximately 85 feet above lake surface, but indications of still lower beaches have been found in the islands of the lake and on Traverse bay.

In lake Agassiz, and in the smaller glacial lakes, sediment was deposited from the rivers which drained the icesheet and the land from which the ice had receded. Where the Assiniboine river entered the lake a great delta was formed, extending eastwards from Brandon 75 miles to Portage la Prairie, northeastwards 50

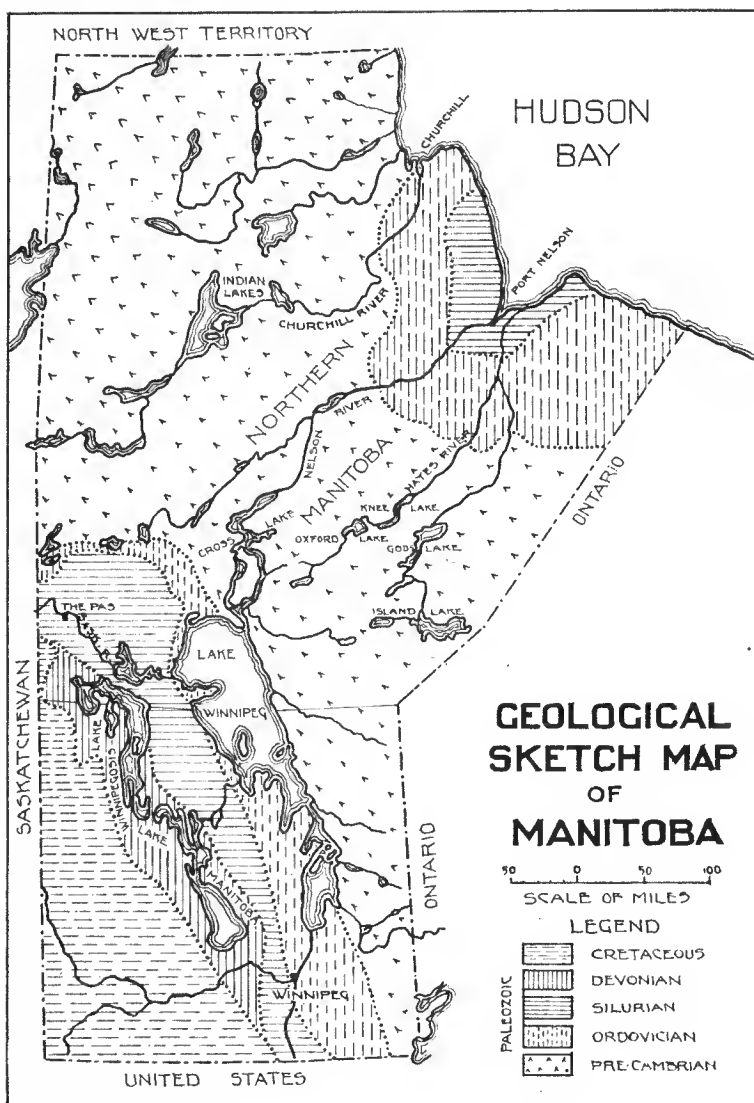


PLATE VIII

The Geological Formations of Manitoba.

miles to Gladstone, and east-southeastwards 80 miles into the Boyne river valley. The sand deposited in this delta has now been to a large extent reassorted as sand dunes. Where the Pembina river entered the lake a smaller delta was formed. The delta formed by the Assiniboine river at an earlier stage as it entered lake Souris (extending northwest from Griswold) has already been referred to. In the deeper parts of lake Agassiz fine silts and clays were deposited, and form finely stratified beds in the Red river valley. Near Winnipeg, the section of the upper 20 feet is as follows:

Soil—4 feet.

Sand beds—3 feet.

Clays (grey friable)—3 feet.

Yellow sandy bed—6 inches.

Clays (grey, finely laminated)—10 feet

The lower clays and upper clays are lacustrine clays. The yellow band represents a time of shallowing, when the lake was almost completely drained. Johnston has suggested that temporarily an outlet may have been found through the ice, which was subsequently blocked. The sand beds were probably deposited by the overflow from the Red river or an earlier stream. The total depth of the glacial deposit is 40-60 feet in the Winnipeg area, the lower half of which is mainly glacial till. Stratified lacustrine beds are not widely distributed over the basin of lake Agassiz. Such beds as were formed in the higher levels of the basin have probably been washed down to the valley and the rivers since glacial times.

Teeth of the mammoth have been found in the beaches of lake Agassiz. Beneath the Herman beach, in North Dakota, there were found a mammoth tusk, three teeth, two vertebrae, and several other bones. In some of the beaches as well, chipped flints, evidently formed by man, have been found. Man came late in this area, but he worked and played on the shores of lake Agassiz as that lake gradually sank to its present dimensions.

(ii). Recent deposits are of small importance. They are delta deposits (at mouth of Red river) river sand or mud bars and levees, lake beaches, peat beds and swamp growths. Since glacial times a drainage system is being evolved on the surface where the former channels were blocked by glacial deposits. The new system is yet immature, and large areas are yet undrained, and in the form of swamps and muskegs are being filled up with plant growth which will ultimately be transformed into peat. The rivers have as yet few tributaries, and relatively narrow valleys. The topography has been little modified since glacial times.

From the economic standpoint the Pleistocene and Recent deposits that are of value are the sand and gravel of the beaches and eskers, used for road construction and building materials, and the clays of postglacial age which immediately underlie the soil covering. These clays have been used in St. Boniface, Portage la Prairie and many other points in the province for the manufacture

of brick. Owing to the high percentage of lime in the clay, they burn as a rule to a pale grey or buff. The stratified clays of lake Agassiz are too stiff, and have too high shrinkage, to be of value for the manufacture of brick or other clay products.

VI. THE PHYSIOGRAPHIC FEATURES OF MANITOBA

The physiographic features of Manitoba are to a great degree dependent on the underlying geological structure. It is therefore possible, in a general way, to define physiographic areas as coterminous with the geological formations: (a) PreCambrian, (b) Palaeozoic, (c) Cretaceous and Tertiary. The features which have been determined mainly by the character and attitude of the underlying rock have been modified by the passage of the ice in Pleistocene times, which has smoothed down many of the sharpest details, and superimposed others of considerable physiographic importance.

(a) *The Physiography of the PreCambrian Surface.*

The PreCambrian territory, consisting of the harder granites or gneissose rocks, and the softer sheared lavas and sediments, was eroded to low level before Palaeozoic times. Since middle Palaeozoic times, it has been re-exposed almost continuously to denudation. The softer rocks, being less resistant, are the most deeply disintegrated. With the passage of the ice sheet the weathered surface was swept away, the schists were plucked to a greater degree than the granite, and there was left a hummocky smooth topography with linear valleys in the bands of schists and sediments. In these valleys the rivers now drain the PreCambrian surface, spilling from one cup-shaped depression to the next. Apart from the general drainage slope, the differences in relief are small, being not over 200 feet as a rule. Any greater differences of relief are due mainly to glacial accumulation on the PreCambrian surface. As the general direction of the ice sheet was southwards, the rounded hummocky roches moutonnees aspect of the topography is more striking as one looks southward than northward.

Many of the lakes lie in the relatively easily eroded schists. The outline of such lakes is determined very definitely by the attitude of the rocks, the long narrow bays being always parallel to the strike of the schist.

(b) *The Physiography of the Palaeozoic Surface.*

The flat-lying limestones of Ordovician, Silurian and Devonian age, exposed in the district of the great lakes in Manitoba, have been less affected by the icesheet, in the major physiographic features which they now display, than were the PreCambrian rocks. The sharp cliff features which often define the edge of the Palaeozoic limestone overlooking the PreCambrian surface, or lakes resting on that surface, were probably made more definite by ice-plucking, but are mainly of erosional origin. A similar origin obtains for the cliffs which are to be seen in the Devonian limestones and dolomites of lake Manitoba and lake Winnipegosis, cutting through the

dome-shaped elevations characteristic of that horizon. Elsewhere the shorelines of Palaeozoic rock are of a low shelving type, with few outcrops and frequent lagoons, bars and spits. The edge of the hard Silurian dolomite is marked by a definite cuesta in the Stonewall—Teulon area. The principal erosion features are the deep old river-valleys east of Fisher Branch, the Stony Mountain monadnock, and the pits and swallow-holes which indicate extensive underground solution in the area between lake Winnipeg and lake Manitoba. In general, the Palaeozoic surface is very flat, and very poorly drained

(c). *The Physiography of the Cretaceous and Tertiary Surface.*

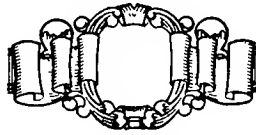
The soft shales of Cretaceous and early Eocene age in South-western Manitoba have suffered intense erosion since they were elevated in Tertiary times. What is left in southwestern Manitoba, from the edge of the Manitoba escarpment westwards, is only a part of the original extent of the Cretaceous rock in southern Manitoba. The erosion along the eastern face of the shales has left a prominent escarpment extending from Pembina hills, through Tiger hills, Riding, Duck and Porcupine mountains, to Pasquia hills. This escarpment has been dissected by valleys formed by the Assiniboine river, Valley river, Swan river and Red Deer river, with other minor streams. The escarpment now stands in isolated blocks, which form the hills above enumerated, rising from an elevation of 900 feet at the base of the escarpment of 2500 feet at the top. The smaller and relatively younger streams which dissect the shales have left exposed high cliffs of shale; and the Cretaceous surface is still in process of being actively denuded to lower level. The hard limestone bands in the Niobrara shales, and the ironstone concretion beds in the Millwood shales, are the most resistant and form the greatest number of outcrops. Elsewhere the soft shales are as a rule partly covered, even on the sides of deep river valleys.

(d). *Physiographic Features of Glacial and Recent Age.*

The main features of Glacial topography have been discussed in connection with Pleistocene geology, and in the preceding sections of this chapter. The moraines, eskers and beaches of glacial origin lie, generally speaking, in a north northwesterly trend. The drainage to the main northgoing channel is by tributary streams from the east and west. The drainage from the west in particular is to a great extent hampered by these glacial ridges. In this way there has formed, between the long ridge of relative dry land extending northwards, large swamps, frequently impassible. This is particularly noticeable in the country between lake Winnipeg and lake Winnipegosis north of the Little Saskatchewan river. Occasionally striking physiographic features result from glacial depositions, such as Brassey hill on the Hayes river, Brandon hills in part, the gravel and sand deposits west of Lac du Bonnet, and the sand dunes of the Assiniboine delta. The blocking of the drainage on the Pembina river at Lang's valley by glacial material

has resulted in the carving out of the Souris river valley below that point. The flat nature of the surface in the Red river valley, and in the Hayes and Nelson river areas, is due to deposition in glacial Lake Agassiz on the one hand, and in a larger Hudson Bay sea on the other. The interrupted drainage caused by glacial deposition is since glacial times only gradually being restored, though not always along the original channels; and, as yet, the drainage is very immature.

Apart from the river valleys of postglacial age, and the preglacial river valleys which have been reopened through the drift in Recent times, the most striking feature of post glacial topography is the high beaches which have been heaped up in our inland lakes. These boulder beaches reach an elevation above lake level of 15 feet in Dawson bay (lake Winnipegosis), and an almost equal height above the lowlying ground behind the beaches. They are doubtless due to the presence of moving ice driven by the wind against the shore line when the lake ice breaks up at the end of each winter season.



VI. BIBLIOGRAPHY OF LITERATURE ON THE GEOLOGY OF MANITOBA

A

- ALCOCK, F. J.
Lower Churchill river region, (XIX, Summary Report of the Geological Survey,
Department of Mines, for the calendar year 1915, pages 133-136)
- ALCOCK, F. J.
The Churchill River. (Geog Review, December, 1916)
- ALCOCK, F. J.
Wekusko Lake Area, Manitoba, (Northern). (Pages 8-17, Summary Report, 1917,
Part D, G S C)
- ALCOCK, F. J.
Reed-File Lakes Area, Manitoba. (Pages 6-8, Summary Report, 1918, Part D,
G S C)
- ALCOCK, F. J.
Wekusko Lake Area, Manitoba. (Pages 9-10, Summary Report 1918, Part D,
G S C)
- ALCOCK, F. J.
The Origin of Gold Deposits in Wekusko Lake. (Bull Can Min Inst Sept 1918)
- ALCOCK, F. J.
Discussion of a paper by R. C Wallace, entitled "Origin of Gold Deposits in the
Canadian PreCambrian." (Can Min Inst. Trans, Vol 21, pages 290-292, 1919)
- ALCOCK, F. J.
Cross-Pipestone Map Area, Manitoba. (Page 11-18, Summary Report, 1919,
Part D, G S C)
- ALCOCK, F. J.
Gold Deposits of Herb Lake District, Manitoba. (Can Min Journ, Nov 1920)
- ALCOCK, F. J.
Past and present trade routes to the Canadian northwest. (Geog Review, Vol 10,
No 2, pages 57-83 24 fig, Aug 1920)
- ALCOCK, F. J.
Ospwagan Lake—Burntwood River Area, Northern Manitoba. (Pages 1-6,
Summary Report 1920, Part C, G S C)
- ALCOCK, F. J.
A local occurrence of differentiation in granite on the Churchill river Northern
Manitoba, Canada. (Roy Soc Can Trans Vol XIV Sec. IV, Pages 31-33, 1 fig.
May, 1920)
- ALCOCK, F. J.
Rat river route from Three Point lake to Southern Indian Lake, Manitoba. (Page
60-120, Summary Report 1920, Part C, G S C)
- ALCOCK, F. J.
The terminal Moraine of the Seal Churchill Divide. (Pages 13-18, Summary
Report 1920 Part C, G S C)
- ALCOCK, F. J (with E. L. BRUCE)
The PreCambrian Rocks of Manitoba. (Bull G S A, June 1921 pages 267-292)
- ALCOCK, F. J.
The Occurrence of Gold at Herb Lake. (Can Inst Min and Metallurg Bull.
No 107, pages 210-215, March, 1921)
- ALCOCK, F. J.
The Reed-Wekusko Map-Area, Northern Manitoba. (Canada Department of
Mines, Geol Surv Memoir 119, 47 pages, 6 pls, 2 maps)
- ALCOCK, F. J.
Flinflon Map-Area, Manitoba and Saskatchewan (Pages 1-36, Summary Report,
1922, Part C, G S C)
- ALCOCK, F. J.
The Pas Mineral Belt. (Can Min Journ Vol 45, No. 30, pages 713-715, 3 figs,
July 25 1924)
- AMI, H. H.
Resources of the Country between Quebec and Winnipeg along the line of the
G. T. P. Railway. (Sessional paper, 143, King's Printer, Ottawa. 1903)
- ANDERSON (Bishop of Rupertsland)
Notes of the flood at the Red river. (Historical and Scientific Society of
Manitoba)
- ARMSTRONG, JOHN
Report of the Preliminary Surveys for a proposed railway to Hudson Bay. (Ses
sional paper No 2019 1910, King's Printer Ottawa)
- ARMSTRONG, P.
Geology and Ore deposits of Elbow Lake area, Northern Manitoba. (Pages 37-44,
Summary Report. 1922 Part C. G S C)

B

- BACK, CAPTAIN**
Narrative of the Arctic Land Expedition. etc., in the years 1833, 1834, and 1835.
(By Capt Back, R N)
- BANCROFT, C. R.**
Prospecting opportunities in Northern Manitoba (Bull Can Min Inst July 1919, Pages 719-721).
- BELL, R.**
Report on the country between Red river and South Saskatchewan with notes on the geology of the region between Lake Superior and Red river. (G S C Report of Progress for 1873-74, pages 66-90)
- BELL, R.**
Report on the country west of lakes Manitoba and Winnipegosis, with notes on the geology of lake Winnipeg. (G S C Report of Progress for 1874-75, Summary Report of the Directors, pages 24-56)
- BELL, R.**
Report on the country between Lake Winnipeg and Hudson Bay (Part C C Report of Progress 1877 to 1878 pages 1-31)
- BELL, R.**
Report on explorations on the Churchill and Nelson rivers and around God's and Island lakes, 1879 (Part C, Report of Progress 1878-79 pages 1-72)
- BELL, R.**
Report on Hudson Bay and some of the lakes and rivers lying to the west of it (G S C, Report of Progress, 1879-89, pages 1-111)
- BELL, R.**
Observations on the geology, mineralogy, zoology and Botany of the Labrador coast, Hudson strait and bay (Part D D, Report of Progress, 1882-84, G S C, pages 3-62)
- BELL, R.**
Explorations on Lake of the Woods, and Wahigoon lake to Red lake, via lac Seul Ontario, and on Lake Winnipeg, and Winnipeg river (in Director's Summary Report, 1883, Annual Report 1882-84, G S C)
- BELL, R.**
"The Geology of Hudson's Bay and Strait" in the report of the Hudson's Bay Expedition, 1885. (Department of Marine, Ottawa)
- BELL, R.**
On Glacial Phenomena in Canada (Bull of the Geol Soc of Am Vol 1 1890 pages 237-310)
- BELL, R.**
Rising of Land around Hudson's Bay. (Report of the Smithsonian Inst for 1897-98 pages 359-367)
- BELL, R.**
Geology and Economic Minerals of Hudson's Bay and Northern Canada (Abstract in Trans Royal Soc Can, Vol II, Sec IV, p 241, Ottawa)
- BELL, R.**
Amygdaloid in Manitoba. (A Summary Report of the Geological Survey Department of Canada for the calendar year 1903, page 9)
- BILLINGS, E.**
Lower Silurian fossils. 3. Fossils of the Chazy limestone, with descriptions of new species. (Extracted from the report for 1853 and 1859 Published in the Canadian Naturalist and Geologist, Oct and Nov 1859)
- BLACK, W. J.**
Economic Resources of Manitoba (In volume 20 Canada and its Provinces, Glasgow, Black and Co., Toronto, 1914)
- BRAMBLE, C. A.**
The Land of the Lobstick (Issued by J A Macdonald, Publicity Commissioner, Manitoba, 1920)
- BROCK, R. W.**
The Hudson Bay Route. (Observations made during a trip with His Excellency the Governor General) (Part A, Summary Report of the Geological Survey branch of the Department of Mines for the calendar year 1910)
- BROWN, HON C. P.**
Report of a Select Committee of the Legislative Assembly of the Province of Manitoba appointed to Procure Evidence as to the Practicability of the Establishment of a System of Communication with the Province via Hudson Bay Printed by order of the Legislative Assembly, Winnipeg, 1884)
- BRUCE, E. L.**
Amisk-lake district, Northern Saskatchewan and Manitoba. (XVI, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1914, pages 67-68)
- BRUCE, E. L.**
Amisk-Athapapuskow lake area, Northern Saskatchewan and Northern Manitoba. (XVII, Summary Report of the Geological Survey, for the calendar year 1915, pages 126-130)

- BRUCE, E. L.
A New Gold Area in Northeastern Saskatchewan and Manitoba. (Can Mining Inst. Trans Vol. XVIII, pages 174-181, 1915)
- BRUCE, E. L.
Schist Lake and Wekusko Lake areas. (Summary Report, 1916, Geol Surv Can, pages 159-178).
- BRUCE, E. L.
Schist Lake District, Northern Manitoba. (Pages 18, Summary Report, 1917, Part D, G S C)
- BRUCE, E. L.
Preliminary Map Amisk-Athapapuskow Lakes Map (No 1692 Geol Surv Can)
- BRUCE, E. L.
Molybdenite near Falcon Lake, Manitoba. (Pages 22-25, Summary Report, 1917, Part D, G S C)
- BRUCE, E. L.
Amisk-Athapapuskow Lake District. (Canada, Dept of Mines, Geol Surv Memoir 105, 91 pages, 7 pls, 4 figs, 1 map, 1918)
- BRUCE, E. L.
Metal mining in Northern Manitoba in 1917 (Can Mining Journ, Dec. 15th, 1917)
- BRUCE, E. L.
Athapapuskow Lake District. Manitoba. (Pages 1-2, Summary Report, 1918, Part D, G S C)
- BRUCE, E. L.
District lying between Reed Lake and Elbow Lake, Manitoba. (Page 2, Summary Report, 1918, Part D, G S C)
- BRUCE, E. L.
Gold-Quartz veins and Scheelite Deposits in Southeastern Manitoba. (Pages 11-15, Summary Report, 1918, Part D, G S C)
- BRUCE, E. L.
Mining in Northern Manitoba (Bull Can Min Inst, pages 262-270, March, 1918)
- BRUCE, E. L.
Prospecting areas in Northern Manitoba. (Man Public Service Bulletin, June, 1918)
- BRUCE, E. L.
Knee-Oxford Area. (Geol Surv Can, Summary Report, Part D, pages 1-11, 1919).
- BRUCE, E. L.
Mining in Northern Manitoba. (Can Min Inst Trans, Vol 21, pages 279-286, 1 fig, 1919).
- BRUCE, E. L.
Knee Lake District, Northeastern Manitoba. (Pages 1-11, Summary Report, 1919, Part D, G S C)
- BRUCE, E. L.
Prospecting Areas in Manitoba (Manitoba Pub Ser. Bulletin, June, 1919)
- BRUCE, E. L.
Chalcopyrite Deposits in Northern Manitoba. (Economic Geology, Vol XV, No 5, July-August, 1920, pages 386-397)
- BRUCE, E. L. (with F J ALCOCK)
PreCambrian Rocks of Manitoba (Bull of the Geol Soc of Am., Vol. 32, pages 267-292, 1921)
- BRUCE, E. L.
The Early PreCambrian Formations of Northern Ontario and Northern Manitoba. (Journ Geol, Vol 30, No. 6, pages 459-471, 1922).
- BRUCE, E. L.
Discussion of a paper by R. C. Wallace, entitled "Prospecting Conditions in Northern Manitoba." (Can Inst. of Min and Metallurgy, Trans Vol 25, 1922, pages 140-141)
- BRYCE, GEORGE
Surface Geology of the Red River and Assiniboine Valleys. (Hist and Scientific Society of Man, Jan 22nd, 1891, 7 pages).
- BRYCE, GEORGE
Everyman's Geology of the Three Prairie Provinces. (Historical and Scientific Society of Manitoba, Winnipeg, 1907)
- BRYCE, GEORGE
Older Geology of the Red River and Assiniboine Valleys. (Historical and Scientific Society of Man, Nov 26th, 1891, 7 pages)
- BURPEE, LAWRENCE J.
The Search for the Western Sea. (The Musson Book Co, Ltd, Toronto, 1908)
- BURPEE, LAWRENCE J.
Pathfinders of the Great Plains. A Chronicle of La Verendrye and his sons. (Chronicles of Canada, Vol 19, Glasgow Brock and Co, Toronto, 1914).
- BUTLER, CAPT. W F.
The Great Lone Land; a Narrative of Travel and Adventure in the Northwest of America. (London, 1872)

C

- CALLINAN, J. W.**
 Finlon Copper District. (Eng and Mining Journ, Feb 17th, 1917, page 303)
- CAMPBELL, C. M.**
 Resources and Characteristics of Northern Manitoba, July, 1919. Reprinted by
 Provincial Government of Manitoba
- CAMPBELL, J. A.**
 Northern Manitoba, Nov. 1917. (Man Gov Pub)
- CAMPBELL, J. A.**
 Manitoba's Northland, Nov. 1918. (Man. Gov Pub)
 Northern Manitoba Mineral Belt (Man Pub Service Bulletin, July, 1918)
- CAMPBELL, J. A.**
 The Northern Copper Country. (Man Pub Service Bulletin, Aug and Oct, 1918)
- CAMPBELL, J. A.**
 Copper and Gold in Manitoba. (Can Min Journ, Vol XXXVIII, No 13, pages
 274-276)
- CAMPBELL, J. A.**
 Mining in Northern Manitoba (Can Min Journ, Vol XXXIX, No 16, page
 273)
- CAMPBELL, J. A.**
 Recent discoveries and developments in Northern Manitoba. (Can Min Journ,
 Vol. XXX, No 21, page 360).
- CHAMBERS, CAPT. E. J.**
 "Canada's Fertile Northland." Containing the evidence heard before the Select
 Committee of 1906-07 and the report based thereon. (Ottawa, Government Print
 ing Bureau)
- CHAMBERS, CAPT. E. J.**
 The Unexploited West. (Published under the Direction of F. C C Lynch, Super
 intendent Railway Lands Branch)
- CHALMERS, R.**
 Mineral Resources of Canada. Bulletin on Peat (Mineral Resources Bulletin,
 Ottawa, 1904 G S C)
- CHALMERS, R.**
 The surface geology of Manitoba Saskatchewan and Alberta. (X Summary Report
 of the Geological Survey Department of Canada for the calendar year 1905, pages
 67-69)
- CHALMERS, R.**
 Surface Geology of the Great Plains and British Columbia, etc (VIII, Summary
 Report of the Geological Survey Department of Canada for 1906 pages 71-80)
- CHEADLE AND MILTON**
 (W. B. Cheadle, M A, and Viscount Milton, M.P.)
 "The Northwest Passage by Land—A Narrative of an Expedition from the
 Atlantic to the Pacific." (London, 1864)
- CLAPP, F. G.**
 Petroleum and Natural Gas Resources of Canada. (Volume 2, Mines Branch, De-
 partment of Mines, Ottawa, 1915)
- COLE, L. H.**
 The Salt Deposits of Canada, and the Salt Industry. (Mines Branch, Department
 of Mines, Ottawa, 1915)
- COLE, L. H.**
 Gypsum in Canada; its occurrence, exploitation and technology. (No 245, Canada
 Department of Mines, Mines Branch, 256 pages)
- COLEMAN, A. P AND PARKS, W. A.**
 Elementary Geology with Special Reference to Canada. (J M Dent and Sons,
 London and Toronto)
- COLLINS, W. H. AND CAMSELL, C.**
 Sudbury, Ontario, to Dunmore, Alberta. (Guide Book No 9, Transcontinental
 Excursion C 2)
- COLLINS, W. H. AND WILSON, M. E.**
 Winnipeg to Cochrane via National Transcontinental Railway. (Guide book No 9,
 Transcontinental excursion C2, G S C)
- COLONY, R. J.**
 A Note of the Sudbury type in Manitoba. (Bull Can Min. Inst No 103,
 November, 1920, pages 862-872)
- COOKE, H. C.**
 Geology and Mineral Resources of Rice Lake and Oiseau River Areas, Manitoba.
 (Summary Report, 1921, Part C, G S C) (36 pages).

D

- DAWSON, G. M.
Note on the occurrence of Foraminifera, coccoliths, etc., in the Cretaceous rocks of Manitoba. (Can. Nat 252-257, 11 (1874)
- DAWSON, G. M.
Meteorological Observations in the Northern Part of British Columbia, the Peace River district, and from Edmonton to Manitoba, June 7th to November 28th. 1879. (G. S. C. Report of Progress for 1879-80, Appendix II, Part B).
- DAWSON, G. M.
Geological character of the country drained by the Assiniboine and Red rivers. (Can. Nat 10: 56-58 (1881)
- DAWSON, G. M.
On certain borings in Manitoba and the Northwest territory. (Trans. Royal Soc Can Vol IV, 4 to pages 85-99, 1887)
- DAWSON, G. M.
On the Glaciation of the Northern Part of the Cordillera, with an attempt to Correlate the Events of the Glacial Period in the Cordillera and Great Plains. (American Geologist, September, 1890)
- DAWSON, G. M.
Notes to accompany a geological map of the Northern portion of the Dominion of Canada. East of the Rocky Mountains. (Queen's Printer, Ottawa, 1887)
- DAWSON, G. M.
Report on the geology and resources of the region in the vicinity of the forty-ninth parallel from the Lake of the Woods to the Rocky Mountains. (British North American Boundary Commission 379 pages, 11 map, Montreal, 1875).
- DELURY, J. S.
The Principles Underlying the Occurrence of Oil and Gas and their Application to Western Canada (Can. Min. Journ., June, 1915, pages 331-333)
- DELURY, J. S.
The Oil and Gas Possibilities of Western Canada. (Can. Min. Journ., July, 1915)
- DELURY, J. S.
Mineral Belt North of the Pas, Manitoba. (Public Utilities Commission Report, 1916)
- DELURY, J. S.
The Manitogotan Gold District, Manitoba. (With map). (Can. Min. Journ., Vol XXXVII, August 1st, 1916, pages 362-364)
- DELURY, J. S.
Molybdenite at Falcon Lake, Manitoba. (Can. Min. Journ., Vol XXXVIII, No 23, December, 1917, pages 460-462)
- DELURY, J. S.
Tungsten Ore Deposits near Falcon Lake, Manitoba. (Can. Min. Journ., Vol XXXIX, No 11, June, 1918, pages 86-88)
- DELURY, J. S.
Recent Developments in Manitoba. (Can. Min. Journ., September, 1919, pages 712-714)
- DELURY, J. S.
Some economic aspects of the Falcon Lake District, Manitoba. (Transactions, Canadian Institute of Mining and Metallurgy, Vol XXII, 1919 pages 320-328)
- DELURY, J. S.
An Occurrence of Tin near the Ontario-Manitoba Boundary. (Can. Min. Journ., Vol XLI, No 25, June 15th, 1920, pages 520-521)
- DELURY, J. S.
Mineral Deposits in Southeastern Manitoba (Rice Lake, Maskwa River, and Boundary Districts). (Manitoba Government Bulletin, 1921)
- DELURY, J. S.
The Mineral Industry in Manitoba 1922. (Can. Min. Journ., January, 1923, pages 20-21)
- DELURY, J. S.
The Mineral Belt North of the Pas, Manitoba. (Can. Min. Journ., Vol XXXVII, page 412)
- DITTMAR, W.
Analysis of the waters of the Hayes and Nelson Rivers. (Appendix V to Part C, Report of Progress for 1879-1880, G. S. C., pages 77-79).
- DOBBS, W. S.
The region south of Cape Tatnam Hudson Bay. (XI Summary Report of the Geological Survey Department for the Calendar year 1905. pages 69-73).

- DOWLING, D. B. AND TYRRELL, J. B.**
Report on the Country between Athabasca Lake and Churchill River, with Notes on Two Routes travelled between the Churchill and Saskatchewan Rivers. (J. B. Tyrrell assisted by D. B. Dowling). (Part D, Annual Report (new series) Vol VIII 1895, G S C, 120 pages)
- DOWLING, D. B. AND TYRRELL, J. B.**
East Shore of Lake Winnipeg. (G S C Annual Report, 1898, Part G, pp 5-98)
- DOWLING, D. B.**
Report on the Geology of the West Shore and Islands of Lake Winnipeg (Part F, Annual Report, 1898, G S C, pages 1-100)
- DOWLING, D. B.**
Report on Geological Explorations in Athabasca, Saskatchewan, and Keewatin Districts, including Moose Lake and the Route from Cumberland Lake to the Churchill River and the Upper Parts of Burntwood and Grass Rivers. (Part F F, Annual Report, 1900, G S C, 44 pages)
- DOWLING, D. B.**
Eastern Assiniboia and Southern Manitoba. NOTE: Contains Notes on Coal-mining; Brick, Cement and Plaster Industries For descriptions of fossils see No. 950. (X, Part C, Summary Report of the Geological Survey Department of Canada for the calendar year 1902, pages 182-192)
- DOWLING, D. B.**
Notes to accompany a Contoured Plan of the Lower Slope of Turtle Mountain, Manitoba. (XI, Part C, Summary Report of the Geological Survey Dept of Canada for the calendar year 1902, pages 193-203)
- DOWLING, D. B.**
Calgary, Alberta, to Winnipeg, Manitoba, via the Grand Trunk Pacific Railway: (Guide Book No 9, Transcontinental Excursion CI, G S C)
- DOWLING, D. B.**
Winnipeg to Bankhead (Guide Book No 8, Part 1, Transcontinental Excursion CI)
- DOWLING, D. B.**
The coal fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia (Memoir 53, G S C No 1363, 1914, 142 pages)
- DOWLING, D. B.**
Coal Fields and Coal Resources of Canada (Memoir No 59, G S C, 1915)
- DOWLING, D. B., SLIPPER, S. E., and McLEARN, F. H.**
Investigations in the Gas and Oil Fields of Alberta, Saskatchewan and Manitoba. (Geological Survey of Canada, Memoir 116, No 1722, 89 pages, 1919)
- DRESSER, J. A.**
Gold-bearing Districts of Southeastern Manitoba. (G S C Summary Report, 1916, pages 169-174)

E

- EDWARDS, ABEL**
Notes taken during the Summer of 1812, on a Journey from York Fort, Hudson's Bay, to Lake Winnipeg, and the Red River, by Mr. Abel Edwards, Surgeon at the Settlement on Red River, together with a Description of the Specimens collected by Mr. Edwards and by Mr. Holdsworth, Surgeon at York Fort (Trans Geol Soc, 1st Series, Vol V, London, 1821 pages 606-607)
- ELLS, R. W.**
Report on the Boring Operations in the North-West Territory, Summer of 1875. (G S C Report of Progress for 1875-1876, pages 281-291)
- ELLS, S. C.**
Cretaceous Shales of Manitoba and Saskatchewan. Their Economic Value as a Possible Source of Crude Petroleum. (Mines Branch, Dept of Mines, Can, Mem Series, December, 1921 No 3)

F

- FERRIER, W. F.**
Petrography of the area on the East Shore of Lake Winnipeg and adjacent Parts of Manitoba and Keewatin. (In Part G, Annual Report, 1898, G S C)
- FRANKLIN, SIR JOHN**
Narrative of a Second Expedition to the Shores of the Polar Sea in 1826 and 1827. (Appendix I, by Dr John Richardson)
- FRANKLIN AND RICHARDSON**
Franklin's Journey to the Polar Sea. (1823)

H

- HAANEL, B. F.
Peat, Lignite and Coal. (Mines Branch, Department of Mines, Ottawa, 1914)
- HANSON, G.
Some Canadian Occurrences of Pyritic Deposits in Metamorphic Rocks. (Economic Geology, Vol XV, No 7, November, 1920, pages 574-609).
- HARDING, W. K.
Field for the Prospector in Manitoba. (Min and Eng World, Vol. XLIV, No 22, pages 993-996)
- HARMON, D. W.
A Journal of Voyage and Travel in the Interior of North America. (Andover, 1820)
- HARRINGTON, B. J.
Notes on Samples of Brick-Clay from Fort Garry; Analysis of Serpentine from Abitibi and Green Mineral from Carboniferous Conglomerate, New Brunswick. (G S C Report of Progress for 1872-73, pages 296-298)
- HEARNE, SAMUEL
"A Journey from Prince of Wales Fort in Hudson's Bay to the Northern Ocean. Undertaken by order of the Hudson's Bay Company for the Discovery of Copper Mines, a North-West Passage, etc, in the years of 1769, 1770, 1771 and 1772" (London, 1795, Dublin, 1796, London, 1887)
- HECTOR, J.
On the Geology of the Country between Lake Superior and the Pacific Ocean (between 48th and 54th parallels of latitude) visited by the Government Exploring Expedition under command of Capt J. Palliser. (Page 439, Journ of the Geol Soc., Vol XIV, 1861)
- HERRINGTON, A. J.
The Evolution of the Prairie Provinces. (Wm Briggs, Toronto, 1911)
- HIND, H. V
Narrative of the Canadian Red River Exploring Expedition of 1857. (London, 1860)
- HOFFMAN, G C
Chemical contributions to the Geology of Canada from the Laboratory of the Survey (Part H, pages 1-25, Report of Progress, 1878-1879, G S C)
- HOFFMAN, G C
Chemical contributions to the Geology of Canada from the Laboratory of the Survey; with table of contents (in separate). (Part M M, pages 1-19, G S C Report of Progress for 1882-1883-1884)
- HOFFMAN, G C
Chemical contributions to the Geology of Canada, from the Laboratory of the Survey (Part M, Annual Report, 1885, G S C, pages 1-29)
- HOFFMAN, G C.
Chemical contributions to the Geology of Canada, from the Laboratory of the Survey. (Part f, Annual Report, 1886, G S C, pages 7-43)
- HOFFMAN, G. C
Chemical contributions to the Geology of Canada, from the Laboratory of the Survey. Part I, pages 5-58, Annual Report, 1887-1888, G S C.)
- HOFFMAN, G. C
Chemical contributions to the Geology of Canada, from the Laboratory of the Survey. (Part R, pages 5-57 Annual Report, 1888-1889, G S C)
- HOFFMAN, G. C
Chemical contributions to the Geology of Canada, from the Laboratory of the Survey. (Part R, pages 5-70, Annual Report (new series) Vol V, 1890-91, G S C)
- HOFFMAN, G. C.
Chemical contributions to the Geology of Canada, from the Laboratory of the Survey. (Part R pages 9-92, Annual Report (new series) Vol. VII, 1892-93, G S C)
- HOFFMAN, G. C.
Report of the section of chemistry and mineralogy. (Part R Annual Report (new series) Volume VII, 1894, pages 12-56).
- HOFFMAN, G. C
Report of the section of chemistry and mineralogy. (Part R Annual Report (new series) Volume IX, 1896, pages 9-51)
- HOFFMAN, G C
Report of the section of chemistry and mineralogy. (Part R Annual Report (new series) Volume XI, 1898 pages 9-53 G S C)
- HOFFMAN, G. C.
Report of the section of chemistry and mineralogy. (Part R Annual Report (new series) Volume XIII, 1900, pages 13-62).
- HOFFMAN, G. C.
Report of the section of chemistry and mineralogy. (Ottawa, 1907 (dated 1906), pages 153-156 G S C)

I

- INGALL, E. D.
Division of mineral statistics and mines. (Part S, Annual Report, 1888-1889, G S C, pages 5-123)
- INGALL, E. D.
Amber, Coal, Gypsum. Division of Mineral Statistics and Mines. (Part S, pages 6-201, Annual Report for 1890, G S C)
- INGALL, E. D.
Nickel, Gas, Division of Mineral Statistics and Mines. (Part SS, pages 110-120, Report for 1891, G S C)
- INGALL, E. D.
Division of Mineral Statistics and Mines. (Coal). (Part S, pages 14-56, Annual Report for 1892, G S C)
- INGALL, E. D.
Section of Mineral Statistics and Mines. (Gypsum). (Part S, Annual Report for 1896 (new series), Volume IX, G S C, pages 55-60)
- INGALL, E. D.
Section of Mineral Statistics and Mines. (Coal). (Part S, Annual Report (new series), Volume XI, 1898 G S C)
- INGALL, E. D.
Section of Mines. Annual Report for 1900. (Gypsum). (Part S, pages 53-58, Annual Report (new series), Volume XIII 1900, G S C)
- INGALL, E. D.
Section of Mines. Annual Report for 1901. (Gypsum). (Part S, pages 53-57, Annual Report (new series), Volume XIV, 1901, G S C)
- INGALL, E. D.
Section of Mines. Annual Report for 1902. (Coal and Salt). N.B.—See also reprints Nos. 851 (coal) and 859 (salt). (Pages 34-43 No. 851, and pages 211-238, No. 859) (Part S, Annual Report (new series), Vol XV 1902-1903, G S C)
- ISBISTER, A. K.
On the Geology of the Hudson's Bay Territories and of Portions of the Arctic and Northwest Regions of America. (Quart. Journ. Geol. Soc., Vol. XI in Am. Journ. Sci. and Arts. Second Series, Vol. XXI, 1856)

J

- JOHNSON, R. A. A.
Mineral Resources of Canada. Bulletin on molybdenum and tungsten. By R. A. A. Johnson, with notes (on molybdenite) by C. W. Willmott. (Mineral Resources Bulletin, Ottawa, 1904, G S C)
- JOHNSON, R. A. A.
Section of Mineralogy. (XXIV, Summary Report of the Geological Survey branch of the Department of Mines for the calendar year 1908).
- JOHNSON, R. A. A.
A List of Canadian Mineral Occurrences. (Memoir, 74, No. 1497, G S C, 275 pages)
- JOHNSTON, W. A.
The Genesis of Lake Agassiz—a confirmation. (Journ. Geol., Vol. 24, No. 7, pages 625-638, 1 fig., 1916)
- JOHNSTON, W. A.
Refractory Clay and Pure Quartz Sand of Swan River Valley. (Pages 37-39, Summary Report, 1917, Part D, G S C)
- JOHNSTON, W. A.
Reconnaissance Soil-Survey of the Area along the Hudson Bay Railway. (Pages 25-36, Summary Report, 1917, Part D, G S C)
- JOHNSTON, W. A.
Superficial Deposits and Soils of Winnipegosis Area, Manitoba. (Page 11-15, Summary Report, 1918, Part D, G S C)
- JOHNSTON, W. A.
Records of Lake Agassiz in southeastern Manitoba and adjacent parts of Ontario, Canada. (Bulletin of the Geological Society of America, Vol. 28, pages 145-148)
- JOHNSTON, W. A.
Winnipegosis and Upper Whitemouth River areas, Manitoba. Pleistocene and Recent deposits (Can. Dept. of Mines, Geol. Survey Memoir 128, 42 pages, 2 figs, 2 maps, 1921)
- JONES, T. R.
Contributions to Canadian micro-palaeontology, part III, 5. On some Ostracoda from the Cambro-Silurian and Devonian rocks. Appendix. Notes on the species of Ostracoda described and figured in Decade III of the Geological Survey of Canada. (Pages 59-99, paging continuous with No. 439, 1858).

K

- KARRI-DAVIS, WALTER**
A new Canadian Mining District. (Min and Scientific Press, Oct 13, 1917, page 534)
- KEELE, JOSEPH**
Clay resources of the western provinces. (XIV, part A, Summary Report of the Geological Survey branch of the Department of Mines for the year 1910)
- KEELE, JOSEPH**
Report on progress of investigation of clay resources. (XVII, Summary Report of the Geological Survey branch of the Department of Mines for the calendar year 1911, pages 234-239)
- KEELE, JOSEPH**
Report on progress of investigation of clay resources (XXXVI, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1913, pages 288-292)
- KEELE, JOSEPH**
Tests of clay and shales from Pembina mountains in southern Manitoba. (Can. Dept. of Mines, Mines Branch, Summary Report, 1916, pages 117-118, 1917)
- KEELE, JOSEPH**
Preliminary report on the clay and shale deposits of the western provinces (See Rcs and Keele)
- KEELE, JOSEPH**
Clay and shale deposits of the western provinces (Memoir No 66, part V, G. S. C.)
- KINDLE, E. M.**
The Silurian and Devonian section of western Manitoba. (XXI, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1912, pages 247-258)
- KINDLE, E. M.**
The Distribution of *Stringocephalus burtoni* in Canada (Roy. Soc of Canada, Vol XV, Third Series, 1921)
- KINDLE, E. M.**
Report of the invertebrate palaeontologist (XXXVIII, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1913)
- KINDLE, E. M.**
The Physical and Biological Characteristics of Certain Types of Marlyte Balls from Manitoba and Michigan. (Trans. G. S. C., Vol XVII, Sect IV, May, 1923, pages 105-113)
- KINDLE, E. M.**
Notes on the geology and palaeontology of the lower Saskatchewan river valley (Museum Bulletin No 21, G. S. C., 25 pages)
- KITTO, F. H.**
The New Manitoba District. (Nat Rcs Intell Serv Department of the Interior, Ottawa, 1918)

L

- LAMBE, L. M.**
Contributions to Canadian Palaeontology, Volume IV, Part 1. A revision of the genera and species of Canadian palaeozoic corals. The *Madreporaria Perforata* and the *Alcyonaria* (Ottawa 1899, G. S. C., 106 pages).
- LAMBE, L. M.**
Contributions to Canadian Palaeontology Volume IV, Part II. A revision of the genera and species of Canadian paleozoic corals. The *Madreporaria Aporosa* and the *Madreporaria Rugosa* (Ottawa, 1900, pages 97-200, continuous with No 684, G. S. C.)
- LAWSON, A. C.**
Report on the geology of the Lake of the Woods region, with special reference to Keewatin (Huronian) (?) belt of the Archaean rocks. (Part CC, pages 5-140, Annual Report 1885, G. S. C.)
- LONG, MAJOR**
Narrative of an Expedition to the source of the St. Peter's River. (Compiled by W. H. Keating, A. M., etc., London, 1825)
- LEVERETT, FRANK**
Earth-Movements in the Minnesota Portion of the Lake Agassiz Basin during and since the Lake occupancy. (Vol 25 1914, Bull. Geol. Soc. Am., pages 34-35)
- LOW, A. P.**
Preliminary report on an exploration of country between Lake Winnipeg and Hudson Bay. (Part F, pages 5-19, Annual Report, 1886, G. S. C.)
- LOW, A. P.**
The Cruise of the Neptune. Dominion Government Expedition to Hudson Bay and the Arctic Islands on Board the D. G. S. "Neptune." 1903-1904. (Ottawa, Government Printing Bureau, 1906)

M

- MACKENZIE, SIR A.**
Voyages from Montreal. (London, 1801, pages 1 XIV and 1 XVI)
- MACLEAN, A.**
Ordovician and Silurian of Stony Mountain and Stonewall, Manitoba. (With a Bibliography). (Guide Book No. 8, Part I, Transcontinental Excursion CI, G S C)
- MACLEAN, A.**
Calgary to Winnipeg, via Canadian Northern Railway. (Guide Book No. 8, Part III, G S C)
- MACLEAN, A.**
The Devonian of Snake Island and south shore of Lake Winnipegosis. (Guide Book No. 8, Part III, G S C)
- MACLEAN, A.**
The Devonian of Dawson Bay, Lake Winnipegosis. (Guide Book No. 8, Part III, G S C)
- MACLEAN, A., and WALLACE, R. C.**
Gypsum and Salt in Manitoba. (XVIII, pages 165-169, Summary Report of the Geological Survey, Department of Mines for the calendar year 1913).
- MACLEAN, A.**
Pembina Mountains, Manitoba. (XVII, pages 69-71, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1915).
- MACLEAN, A.**
Pembina Mountain, Manitoba. (XVIII, pages 131-133, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1915).
- MACCOUN, JOHN**
Manitoba and the Great Northwest (London, 1882)
- MACCOUN, JOHN**
On explorations along the line of the Grand Trunk Pacific railway between Portage la Prairie and Edmonton. (IX, pages 81-86, Summary Report of the Geological Survey Department of Canada for the calendar year 1906).
- MALCOLM, W.**
Oil and gas prospects of the northwest provinces of Canada. (Memoir No. 29, G S C, 1913)
- MARSHALL, J. R.**
Gold-bearing District of Southeastern Manitoba. (Pages 17-21, Summary Report, 1917, Part D, G S C)
- MARSHALL, J. R.**
Star Lake Area, Manitoba. (Pages 21-22, Summary Report, 1917, Part D, G S C)
- MAYNARD, J. E., and WALLACE, R. C.**
The Clays of the Lake Agassiz Basin. Their Colloidal Content. (Trans. Roy Soc Can., XVIII, Sect. IV, 1924, pages 9-30)
- MILTON AND CHEADLE, (Viscount Milton, M.P., and W. B. Cheadle, M.A., M.D.)**
"The Northwest Passage by Land; A Narrative of an Expedition from the Atlantic to the Pacific." (London, 1864)
- MITCHELL, P. H.**
Water Powers of Canada. The Prairie Provinces. Dominion Water Power Branch, Department of the Interior, 1916.

Mc

- MOORE, E. S.**
Region east of the south end of Lake Winnipeg. (XXII, pages 262-270, Summary Report of the Geological Survey, Department of Mines, for the Calendar year 1912)
- McCANN, W. S.**
The Maskwa River Copper-Nickel Deposit, Southeastern Manitoba. (Pages 19-29, Summary Report 1920, Part C, G S C)
- McCHARLES, A.**
The Footsteps of Time in the Red River Valley. (Hist. and Scientific Soc of Manitoba, December 16th, 1886, 18 pages)
- McINNES, W.**
Explorations along the proposed line of the Hudson Bay Railway. (X, pages 87-98, Summary Report of the Geological Survey Department of Canada for the calendar year 1906)
- McINNES, W.**
Pasquia Hills and Lower Carrot River region. (VII, Summary Report of the Department of Mines, Geological Survey Branch, for the calendar year 1907).
- McINNES, W.**
Explorations on the Churchill River and South Indian Lake. (XI, Summary Report of the Geological Survey Branch of the Department of Mines for the calendar year 1908)

- McINNES, W.
Geol. Survey of Canada Summary Report, 1910, page 168.
- McINNES, W.
The basins of Nelson and Churchill rivers. (Memoir No. 30, G. S. C., 1914).
- McKENNA, J. A. J.
The Hudson's Bay Route; a Compilation of Facts with Conclusions. (Government Printing Bureau, Ottawa, 1908).
- McLEARN, F. H.
Notes on the cores of Winnipeg wells. (XVIII, page 72, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1914).
- McLEARN, F. H., and SLIPPER, S. E., and DOWLING, D. B.
Investigations in the Oil and Gas Fields of Alberta, Saskatchewan and Manitoba. (Geological Survey of Canada, Ottawa, 1919, Memoir 116 No. 1722, 89 pages).

O

- O'SULLIVAN, O.
A survey of the coast of Hudson Bay from York Factory to Severn River. (XII, Summary Report of the Geological Survey Department of Canada for the calendar year 1905, pages 73-76)
- O'SULLIVAN, O.
On explorations along the proposed route of the Canadian Northern railway, between Split Lake and Fort Churchill. (XI, pages 99-102, Summary Report of the Geological Survey Department of Canada, for the calendar year 1906)
- OWEN, D. D.
Report of a Geological Survey of Wisconsin, Iowa, and Minnesota, by David Dale Owen, United States Geologist, Philadelphia, 1852.

P

- PANTON, J. H.
Red River Valley Gleanings from the Outcrop of Silurian Strata. (Vol. 131, Man. Pamphlet, No. 6, 1884)
- PANTON, J. H.
Gleanings from the Geology of the Red River Valley. (Hist. and Scientific Society of Manitoba, December 28th, 1882, 10 pages).
- PANTON, J. H.
Notes on the Geology of some Islands in Lake Winnipeg. (Hist. and Scientific Society of Manitoba, January 25th, 1886, 10 pages).
- PALLISER, CAPT. R. A.
Explorations—British North America. (British Parliamentary Papers, 1859-1860-1863 1865)
- PALLISER, CAPT. R. A.
Papers relating to the exploration of the country between Lake Superior and the Red river settlement, page 106, folio London, Gov., 1859.
- PARKS, W. A.
Building Stones of Canada. (Vol. IV, 1916, 333 pages, Mines Branch, Department of Mines)
- PARKS, W. A. and COLEMAN, A. P.
Elementary Geology with Special Reference to Canada. (J. M. Dent and Son, London and Toronto, 1923).
- PARSONS, A. L.
Winnipeg to Port Arthur. (Guide Book No. 8, Part III, G. S. C.)

R

- RICHARDSON, SIR JOHN
"Arcic Searching Expedition" London, 1851.
- RICHARDSON AND FRANKLIN
Journey to the Polar Sea. (1823).
- RIES, H.
Report on progress of investigation of clay resources. (XVI, pages 225-232 Summary Report of the Geological Survey branch of the Department of Mines for the calendar year 1911).
- RIES, H. and KEELE, J.
Preliminary report on the Clay and Shale deposits of the western provinces. Memoir No. 24, G. S. C., 1912)
- RIES, H. and KEELE, J.
Report on the Clay and Shale deposits of the western provinces. (Memoir No. 25, G. S. C., 1914)

- ROWAN, J. H.
The Red River. (Hist and Scientific Society of Manitoba, April 24th, 1884, 12 pages)
- RUST, D.
Contributions to Canadian micro-palaeontology, part IV, 6. Radiolaria from the Pierre formation of northwestern Manitoba. (Pages 101-110, continuous with No 440, G S C, 1892).

S

- SAVAGE, T. E.
Geology of the Area of Palaeozoic in the Vicinity of Hudson and James Bays, Canada. (Vol 28, page 171, Bulletin of the Geological Society of America, 1917)
- SAVAGE, T. E.
Silurian of Hudson Bay Region. (Vol 30, page 367, Bulletin of the Geological Society of America, 1919)
- SAVAGE, T. E., and VAN TUYL FRANCIS M.
Geology and Stratigraphy of the Area of Palaeozoic Rocks in the vicinity of Hudson and James Bays (Vol 30, page 339, Bulletin of the Geological Society of America, 1919)
- SCUDDER, S. H.
Contributions to Canadian Palaeontology, Volume II, Part I Canadian fossil insects, myriapods and arachnids. 2. The coleoptera hitherto found fossil in Canada. G S C No 575.
- SELWYN, A. R. C.
Notes of a preliminary geological reconnaissance from lake Superior, by the English and Winnipeg rivers to Fort Garry (G S C Report of Progress for 1872 to 1873, pages 8-18)
- SELWYN, A. R. C.
Report of operations in Manitoba with the diamond-pointed steam drill, 1873 (Pages 12-16, Appendix II to Summary Report by A R C Selwyn, 1873)
- SELWYN, A. R. C.
Observations in the North West Territory on a journey across the plains, from Fort Garry to Rocky Mountain House, returning by the Saskatchewan river, and lake Winnipeg. (G S C Report of Progress for 1873-74, pages 17-62)
- SELWYN, A. R. C.
Notes on boring operations for coal and water at Rat creek and the vicinity of Fort Ellice, Man., and on Swan River near Fort Pelly, Sask. (G S C Report of Progress for 1874-1875, pages 1-16 Summary Report of the Director)
- SELWYN, A. R. C.
Report on boring operations in the Souris River Valley, 1880. (G S C Report of Progress for 1879-80) (Part A, pages 1-10)
- SELWYN, A. R. C.
Report on boring operations in the Souris River Valley, 1880 (Part A, pages 1-10, Report of Progress, 1879-80, G S C)
- SELWYN, A. R. C.
Exploration of A. S. Cochrane east and north of Lake Winnipeg. (Summary Report of the Director for 1882, pages 1-28, G. S. C Report of Progress for 1880-81-82)
- SELWYN, A. R. C.
Notes on explorations on White Mud and Souris rivers, Manitoba. (Summary Report of the Director for 1882, pages 1-28, G S. C Report of Progress for 1880-81-82)
- SELWYN, A. R. C.
Notes on an examination of the Souris River coal-area, Manitoba (G S C Summary Report of the Director, 1883, pages 1-24 Report of Progress for 1882-83-84).
- SELWYN, A. R. C.
Notes on some cretaceous rocks with indications of oil, along the Assiniboine River, Manitoba. (G S C page 38, Summary Report for 1885, being Part II, Annual Report of the Department of the Interior, 1885)
- SELWYN, A. R. C.
Notes on investigations bearing on the water supply in the Northwest. (Summary Report of the operations on the Geological and Natural History Survey to Dec 31, 1889, being Part III, Annual Report of the Department of the Interior, 1889)
- SELWYN, A. R. C.
Artesian wells at Deloraine and Morden, Man. (Page 9A, Summary Report of the Geological Survey Department for the year 1890).
- SELWYN, A. R. C.
Notes on Turtle Mountain coal-field, Manitoba. (Pages 11-12, Part A, Summary Report of the Geological Survey Department for the year 1890).
- SELWYN, A. R. C.
Notes on the Artesian Well at Deloraine, Man. (Pages 26-36, Part A Summary Report of the Geological Survey Department for the year 1891)

- SELWYN, A. R. C.
Notes on the Turtle Mountain coal-field, Manitoba. (Page 4A, Summary Report for 1892, G S C)
- SELWYN, A. R. C.
Notes on the Artesian Wells at Deloraine, Manitoba. (Pages 2A, 6a-8a. Summary Report for 1892, G S C)
- SELWYN, A. R. C.
Notes on the Artesian Well at Deloraine, Manitoba. (Summary Report of the Geological Survey Department for the year 1893).
- SHUTT, F. T.
Western Prairie Soils—Their Nature and Composition. (Department of Agriculture, Ottawa, 1910)
- SHUTT, F. T.
Alkali Soils. (Department of Agriculture, Ottawa).
- SIMPSON, SIR GEORGE
Narrative of a Journey Around the World during the years of 1841 and 1842. (London, 1847)
- SLIPPER, S. E., DOWLING, D. B. and McLEARN, F. H.
Investigations in the Oil and Gas Fields of Alberta, Saskatchewan and Manitoba. (Geological Survey of Canada, Ottawa, 1919, Memoir 116, No 1722, 89 pages)
- SPENCER, J. W.
Report on the country between the upper Assiniboine river and Lakes Winnipegosis and Manitoba. (G S C Report of Progress for 1874-1875, pages 57-70).
- SPENCER, J. W.
Elevations in the Dominion of Canada, (Bulletin of the United States Geological Survey, 1884, page 43, Bulletin No 6)

T

- TYRRELL, J. B.
Explorations in northwestern Manitoba in 1887. (Annual Report Dept. of Int., 1887, Part III, Pages 11-14, Ottawa Annual Report G S C, Vol III, N S 1887-88, Part A, pages 14-18, Montreal, 1889).
- TYRRELL, J. B.
Explorations around lake Manitoba in 1888. (Annual Report Dept. of Int. 1888, Part III, pages 12-14, Ottawa Annual Report G S C, Vol III, N S, 1887-88, Part A, pages 72-75, Montreal, 1889).
- TYRRELL, J. B.
Notes to accompany a preliminary map of the Duck and Riding mountains in northwestern Manitoba. (Part E, pages 5-16, Annual Report, 1887-88, G S C)
- TYRRELL, J. B.
Gypsum Deposits in northern Manitoba. (Can Record of Science, Vol. III, April, 1889, pages 353-360).
- TYRRELL, J. B.
Explorations in northwestern Manitoba in 1889. (Annual Report Dept. of Int. 1889, Part III, pages 12-18, Ottawa Annual Report, G S C, N. S. Vol IV, 1888-89, Part A, pages 15A-25A, Montreal, 1890).
- TYRRELL, J. B.
Explorations in northern Manitoba in 1890. (Annual Report, G S C, Vol. V, N. S., 1890, Part A, pages 26-36)
- TYRRELL, J. B.
Post-Tertiary Deposits of Manitoba and the adjoining Territories of Northwestern Canada. (Bull. of the Geol. Soc. of Am., Vol 1, 1890, pages 395-410)
- TYRRELL, J. B.
Report on northwestern Manitoba, with portions of the adjacent districts of Assiniboia and Saskatchewan. (Part E, pages 5-231, Annual Report, 1890-91).
- TYRRELL, J. B.
Foraminifera and Radiolaria from the Cretaceous of Manitoba. (Royal Soc. of Canada, Vol VIII, Section IV, 1890, pages 111-115).
- TYRRELL, J. B.
The Cretaceous in Manitoba. (Am Journ Scienc. 3rd Series, Vol. VI, September, 1890, pages 227-232)
- TYRRELL, J. B.
Explorations in Northern Manitoba in 1891. (Annual Report G. S. C., Vol. V, 1891, Second Part A, pages 19-25)
- TYRRELL, J. B.
Pleistocene of the Winnipeg Basin. (Amer Geologist, Vol. VII, July, 1891, pages 19-28)
- TYRRELL, J. B.
Three Deep Wells in Manitoba. (Trans Royal Soc. of Canada, Vol. IX, Sec IV, 1891, pages 91-104)

- TYRRELL, J. B.**
Introduction of Dr. Rust's Report on Cretaceous Radiolaria from Manitoba. (Geol Surv Canada Contributions to Can Micro Pal 1892)
- TYRRELL, J. B.**
Explorations between Athabasca Lake and Churchill River. (Annual Report G S C, Vol VI, 1892-3, Part A, (1892), pages 12-25)
- TYRRELL, J. B.**
Deep Well at Deloraine, Manitoba. (Am. Geol., Vol XI, No 5, May, 1893, pages 332 to 342)
- TYRRELL, J. B.**
Notes on the Pleistocene of the North-West Territories of Canada, etc. (Geol Mag September, 1894, pages 394 399).
- TYRRELL, J. B.**
Explorations East of Lake Winnipeg in 1895. (Annual Report G S C Vol. VIII, 1895, Part A, pages 39-45)
- TYRRELL, J. B., and DOWLING, D. B.**
Report on the country between Athabasca Lake and Churchill River, with notes on two routes travelled between the Churchill and Saskatchewan rivers. (By J. B Tyrrell, assisted by D. B. Dowling). (Part D, pages 5-117, Annual Report (new series) Volume VIII, 1895, G S C)
- TYRRELL, J. B.**
Explorations North of Lake Winnipeg in 1896 (Annual Report G S C Vol IX 1896, Part A, pages 31-34).
- TYRRELL, J. B.**
Is the land around Hudson Bay at present rising? (Am Journ of Science, Vol II, September, 1896, pages 200 205)
- TYRRELL, J. B.**
Report on the Dubawnt, Kazan and Ferguson rivers, and the northwest coast of Hudson Bay, and on two overland routes from Hudson Bay to Lake Winnipeg (Part F, pages 5-190, Annual Report, 1896, G S C)
- TYRRELL, J. B.**
Chippewyan names of places in the country here reported on. (Appendix I, part F, pages 194 195, Annual Report, 1896, G S C)
- TYRRELL, J. B.**
The Genesis of Lake Agassiz.
November, 1896, pages 811-815)
- TYRRELL, J. B.**
Explorations in Northwest Manitoba in 1897 (Annual Report G S C. 1897, Vol 10, Part A, pages 34 38)
- TYRRELL, J. B.**
The Glaciation of North Central Canada (Rep Brit Assn 1897 (Abstract) pages 662 663, Journal of Geol., February, 1898, pages 147 160)
- TYRRELL, J. B.**
The Cretaceous of Athabasca River, (Manitoba References). (Ott. Naturalist, Vol 12, No 2, May, 1898, pages 37-41)
- TYRRELL, J. B.**
Report on the east shore of Lake Winnipeg and adjacent parts of Manitoba and Keewatin. (Part G, Annual Report, 1898, G S C)
- TYRRELL, J. B.**
List of Glacial Striae (Part G, pages 86 88, Appendix I, Annual Report, 1898, G S C)
- TYRRELL, J. B.**
Notes on early travellers on Lake Winnipeg whose records or reports contain descriptions referring to the lake. (Appendix II, Part G, pages 89 98, Annual Report, 1898, G S C)
- TYRRELL, J. B.**
Quotations in Dowling's Report on West side of Lake Winnipeg. (Dowling's Report on West Shore of Lake Winnipeg, Annual Report G S C, Vol XI, Part F, 1898)
- TYRRELL, J. B. and DOWLING, D. B.**
East shore of Lake Winnipeg. (G S C Annual Report, 1898 Part G, pages 5-98)
- TYRRELL, J. B.**
Dominion of Canada and Newfoundland. (International Geography, London, 1899, (Newnes and Co), pages 679-707).
- TYRRELL, J. B.**
Report on explorations in the north-eastern portion of the district of Saskatchewan and adjacent parts of the district of Keewatin. (Part F, pages 5 37, Annual Report, 1900, G S C)
- TYRRELL, J. B.**
Stability of the land around Hudson Bay. (Geol Mag June, 1900, pages 266-267)
- TYRRELL, J. B.**
Minerals and Ores of Northern Canada. (Jour. Can. Min Inst Vol. XI, 1908, pages 348-365).

- TYRRELL, J. B.
Geology of Western Canada. (Report Brit Assn. 1909, pages 471-472).
- TYRRELL, J. B.
Changes of Climate in Northwestern Canada since the Glacial Period. (11th Intern Geol Congress, Stockholm, 1910).
- TYRRELL, J. B.
Ice in Canadian Lakes (Trans of the Can Inst., Vol IX, 1910, pages 13-21).
- TYRRELL, J. B.
Hearne's Journey, Introduction and Notes. (Champlain Society, Toronto, 1911)
- TYRRELL, J. B.
Hudson Bay Exploring Expedition, 1912 (22nd Report Ontario Bureau of Mines, 1913)
- TYRRELL, J. B.
Artesian Water in Manitoba (Can Engineer April 9th, 1914, pages 574-575).
- TYRRELL, J. B.
The Patrician Glacier, south of Hudson Bay. (Intern Geol Congr XII, 1914, pages 523-534)
- TYRRELL, J. B.
Pre-Cambrian Goldfields. (Econ Geol July August, 1915, pages 475-477)
- TYRRELL, J. B.
Notes on the Geology of Nelson and Hayes Rivers. (Trans Royal Soc Can 1916, pages 1-27)
- TYRRELL, J. B.
Early Exploration of the Churchill River (Geographical Review, May, 1917, pages 375-381)
- TYRRELL, J. B.
Remarks on Lake Agassiz (discussion). (Bulletin of the Geol Soc Am., Vol 28, 1917, pages 146-148)
- TYRRELL, J. B.
Hudson Bay Limestone. (Bulletin of the Geol Soc of Am Vol 30, 1919, page 355)
- TYRRELL, J. B.
Evidence before Senate Committee on Hudson Bay. (The Senate 4th Sess 13th Parl., 1920)
- TYRRELL, J. B.
Mining in Canada (Science, Vol LVI, Jan 12, 1923, pages 31-38)
- TYRRELL, J. B.
"Thompson's Narrative of his explorations in Western America" (Champlain Society)
- TYRRELL, J. B.
On the Superficial Geology of the Central Plateau of North-Western Canada. (Abstract) (Nature, Vol 39, page 95)
- TYRRELL, J. B.
Pre-Cambrian Goldfields of Central Canada. (Trans Roy Soc Can Sec 3, Vol IX, Sec IV, 1915, pages 89-118).

U

- UGLOW W. L.
Port Arthur to Winnipeg via Canadian Northern railway. (Guide book No 3, Part I Transcontinental Excursion C I, G S C)
- ULRICH, E. O.
Contributions to the Micro-Palaeontology of the Cambro-Silurian rocks of Canada. Part II, 4. On some Polyzoa (Bryzoa) and Ostracoda from the Cambro-Silurian rocks of Manitoba. (Continuous paging with No. 438, G S C)
- UPHAM, W.
Terminal Moraine of the North American Ice-Sheet. (Am. Jour Sc., Vol 18, 1879, pages 81-92, 197-209)
- UPHAM, W.
The Upper Beaches and Deltas of the Glacial Lake Agassiz (Bulletin 39, United States Geological Survey, 1887, 84 pages)
- UPHAM W.
Report of exploration of the Glacial Lake Agassiz in Manitoba. (Part E, pages 5-181, Annual Report, 1888-1889, G. S. C)
- UPHAM, W.
Courses of glacial striae. (Region of Hudson Bay and Lake Superior, and westward. From observations by R. Bell, A. S. Cochrane, and others). (Appendix I, Part E, Annual Report (new series), Volume IV, 1888-1889, G. S. C)
- UPHAM, W.
Birds' Hill, an Esker near Winnipeg, Manitoba. (Bulletin of the Geol Soc. of Am., Vol. 21, pages 407-432, pl 31, Pub. July 20th, 1910).
- UPHAM, W.
Revision of the map of Lake Agassiz. (Journ. Geol., Vol. 23, No. 8, pages 780-784, 1915).

- UPHAM, W.
Fields of Outflow of the North American Ice-Sheet. (Etude Faite A la XIIeme Session du Congres Geologique International, reproduite du Compte-Rendu)
- UPHAM, W.
Table of altitudes. (From railway surveys, and other sources of information Annual Report, G S C., 1890)
- UPHAM, W.
The Glacial Lake Agassiz. (Monograph XXV, United States Geological Survey, 1895).

V

- VAN TUYL, FRANCIS M.
Geology of the area of Palaeozoic rocks in the vicinity of Hudson and James Bays, Canada. (Volume 28, 1917, page 171, Bulletin of the Geological Society of America).
- VAN TUYL, FRANCIS M. and SAVAGE, T. E.
Geology and Stratigraphy of the Area of Palaeozoic rocks in the vicinity of Hudson and James Bays. (Vol 30, 1919, page 339, Bulletin of the Geological Society of America)

W

- WALLACE, R. C.
Gypsum and Brines in Manitoba. (XIX. Summary Report of the Geological Survey, for the calendar year 1914 pages 73-80)
- WALLACE, R. C. and MACLEAN, A.
Gypsum and Salt in Manitoba. (XVII, Summary Report of the Geological Survey, Department of Mines, for the calendar year 1913, Sessional Paper No. 26, pages 165-169)
- WALLACE, R. C.
Pseudobrecciation in Ordovician Limestones in Manitoba. (The Journal of Geology, Vol XXI, No. 5, July August, 1913, pages 402-421)
- WALLACE, R. C.
A Contribution to the Study of Dolomitization. (Transactions of the Royal Soc of Canada, 1913, Vol VII, pages 139-149)
- WALLACE, R. C.
The Rice Lake Gold District in Manitoba (Transactions Canadian Mining Institute, 1913, Vol XVI, pages 538-544)
- WALLACE, R. C.
The Mineral Resources of the Provinces. (The Prairie Provinces, 1914, (Sells, Limited).)
- WALLACE, R. C.
The Salt Industry in Western Canada. (Mississippi Valley Historical Association, Vol VII, 1914, pages 277-285)
- WALLACE, R. C.
Gypsum and Anhydrite in Genetic Relationship. (Geological Magazine, Decade VI, Vol. I, June, 1914, pages 271-276)
- WALLACE, R. C.
Geology of the District between Red and Winnipeg Rivers. (G. S. C. Report, 1916, pages 175-178)
- WALLACE, R. C.
The Corrosive Action of Certain Brines in Manitoba. (The Journal of Geology, Vol XXV, No. 5, July August, 1917, pages 459-466)
- WALLACE, R. C.
The Resources of Manitoba and their Development. (Nov 1918, University of Manitoba Publication, 64 pages)
- WALLACE, R. C.
The Origin of Gold Deposits in the Canadian Pre-Cambrian (Bulletin of the Canadian Mining Institute, No. 74, June, 1918, pages 538-540)
- WALLACE, R. C.
Mining and Mineral Prospects in Northern Manitoba (Northern Manitoba Bulletins, Office of the Commissioner of Northern Manitoba, 1919, 47 pages).
- WALLACE, R. C.
The Gold Discovery at Copper Lake, Manitoba. (Can Mining Journ., Oct. 1, 1919, page 731)
- WALLACE, R. C.
Annual Report of the Commissioner of Northern Manitoba for 1919. (Manitoba Sessional Papers, 1920)
- WALLACE, R. C.
Some Aspects of the Mining Situation in the Middle West. (Bulletin of the Canadian Institute of Mining and Metallurgy, No. 98, June, 1920, pages 477-485).

- WALLACE, R. C.**
The Search for Oil in the Pasquia Hills. (Can. Min. Journ., Vol. XLII, No. 27, July 8, 1921, pages 540-42).
- WALLACE, R. C.**
The Gold Discovery at Elbow Lake. (The Can. Min. Journ., Vol. XLII, No. 35, Sept. 9th, 1921, page 720)
- WALLACE, R. C.**
Report and Recommendation with reference to proposed railway from the Pas to the Flin-Flon Property. (Issued by the Legislature of Manitoba, January 31, 1921, 19 pages)
- WALLACE, R. C.**
The Control of the Mineral Resources of the Prairie Provinces. (Bulletin of the Canadian Institute of Mining and Metallurgy, No. 113, September, 1921, pages 795-802)
- WALLACE, R. C.**
Annual Report of the Commissioner of Northern Manitoba for 1920. (Manitoba Sessional Papers, 1921)
- WALLACE, R. C.**
Secondary Processes in Some Pre-Cambrian Ore-bodies. (Transactions Royal Society of Canada, XVI, 1922, pages 169-179)
- WALLACE, R. C.**
Manitoba's Contribution to Canada's Mining Opportunities. (The Canadian Institute of Mining and Metallurgy, Bulletin No. 143, March 1924, pages 90-99)
- WALLACE, R. C.**
The Rice Lake Gold District. The District North of the Pas. (4 pages) The Star Lake District (with J. S. DeLury, 16 pages, 3 maps) (Industrial Bureau Publication, 1916)
- WALLACE, R. C.**
Sulphide Deposits of Flin Flon and Schist Lakes, Manitoba. (Can. Min. Journ., Vol. XXXVII, page 468).
- WALLACE, R. C.**
Manitoba Gold Belt Prospects. (Eng. and Mining Journal, Vol. 102, page 332)
- WALLACE, R. C. and MAYNARD, J. E.**
The Clays of the Lake Agassiz Basin. Their Colloidal Content. (Trans. Roy. Soc. Can., XVIII, Sect. IV, 1924, pages 9-30)
- WALLACE, R. C.**
Relationships in Mineral Deposits in Northwestern Manitoba. (Economic Geology, Vol. XX, No. 5, August, 1925, pages 431-441)
- WAUD, W. B.**
Report of operations in Manitoba with the diamond-pointed steam drill, 1873. (Appendix II to Summary Report by A. R. C. Selwyn) (G. S. C. Report of Progress for 1873-1874, pages 12-16)
- WELLS, J. W.**
Preliminary report on Limestones and the Lime Industry of Manitoba. (Canada Department of Mines, Mines Branch, Report No. 7, 1905)
- WELLS, J. W.**
Preliminary report of Clays and Shales in Manitoba; their industrial value. (Canada Department of Mines, Mines Branch, Report No. 8, 1905)
- WELLS, J. W.**
Preliminary report on Hydraulic Cements (raw materials) in Manitoba; manufacture and uses of. (Canada Dept. of Mines, Mines Branch, Report No. 9, 1905)
- WHITEAVES, J. F.**
On some Silurian and Devonian Fossils from Manitoba and the valleys of the Nelson and Churchill rivers, for the most part collected by Dr. R. Bell in the summer of 1879. (Appendix I to Part C, Report of Progress, 1878-79, G. S. C., pages 45-51)
- WHITEAVES, J. F.**
List of Fossils collected by Dr. R. Bell in Manitoba during the season of 1880. (G. S. C. Report of Progress 1879-80, page 57, Appendix I, to Part C)
Palaeozoic Fossils, Volume III, Part IV, 5 The Fossils of the Silurian (Upper Silurian) Rocks of Keewatin, Manitoba, the Northeastern Shore of Lake Winnipegosis, and the Lower Saskatchewan River.
B1. From Stonewall. Collected by T. C. Weston in 1884, by D. B. Dowling in 1891 and 1902, and by J. B. Tyrrell and W. H. Robson in 1897.
B2. From Davis Point, Lake Manitoba. Collected by J. B. Tyrrell and J. F. Whiteaves in 1888.
C. From the Northeast Shore of Lake Winnipegosis. Collected by Mr. J. B. Tyrrell in 1889.
D. From the Lower Saskatchewan. Collected by Mr. J. B. Tyrrell in 1889 and 1890, and by Mr. D. B. Dowling in 1891.
6. The Canadian species of Plectoceras and Barrandeoceras. (G. S. C., 1906).

- WHITEAVES, J. F.**
Descriptions of eight new species of fossils from the Cambro-Silurian rocks of Manitoba. (Trans Roy Soc Can., Vol. VII, Sec IV, 4 to pages 75-83, 1889)
- WHITEAVES, J. F.**
Descriptions of some previously unrecorded species of fossils from the Devonian rocks of Manitoba. (Trans Roy Soc Can., Vol VIII, Sec IV, 4 to pages 93-110, 1890)
- WHITEAVES, J. F.**
Contributions to Canadian Palaeontology, Vol. I, Part II, 4. On some Cretaceous fossils from British Columbia, the Northwest Territory, and Manitoba. (G. S. C., 1889)
- WHITEAVES, J. F.**
Contributions to Canadian Palaeontology, Vol. I, Part IV, 6. The fossils of the Devonian rocks of the islands, shores, or immediate vicinity of lakes Manitoba and Winnipegosis. (Pages 111, 255-360, G. S. C., 1891)
- WHITEAVES, J. F.**
Palaeozoic Fossils Volume III, Part II. 2. Revision of the fauna of the Guelph formation of Ontario, with descriptions of a few new species. 3. Systematic list, with references, of the fossils of the Hudson River or Cincinnati formation at y Mountain, Manitoba (G. S. C., 1895)
- WHITEAVES, J. F.**
Palaeozoic Fossils, Vol III, Part III. 4. The fossils of the Galeno-Trenton and Black river formations of Lake Winnipeg and its vicinity. (Pages 129-242, G. S. C., 1897)
- WHITEAVES, J. F.**
Catalogue of the Marine Invertebrates of eastern Canada. (Pages III, 272, Ottawa, 1901, G. S. C.)
- WHITEAVES, J. F.**
Descriptions of eight new species of fossils from the (Galena) Trenton limestones of Lake Winnipeg and the Red River valley. (Can Rec Sci, Vol VI, pages 387-397, 1895)
- WHITEAVES, J. F.**
Notes on some Fresh Water Shells from Manitoba. (Ottawa Nat., Vol. XX, pages 239-240, 1907)
- WHITE, JAMES**
Altitudes in Canada (Commission of Conservation, Ottawa, 1915).
- WILLIMOTT, C. W.**
Mineral Resources of Canada. Bulletin on Molybdenum and Tungsten, by R. A. A. Johnston, with notes (on molybdenite) by C. W. Willimott. (Mineral Resources Bulletin, Ottawa, 1904, G. S. C.)
- WILLIMOTT, C. W.**
The Mineral Pigments of Canada. (Mineral Resources Bulletin, G. S. C., 1906)
- WILSON, BECKLES**
The Great Company. (The Copp, Clark Co., Ltd., Toronto, 1899)
- WOOD, W.**
York Factory. Seasonal or periodic events. (Appendix VI, G. S. C. Report of Progress for 1879 to 80, Part C, pages 80-81)
- WOOD, W. and MASON, J. R.**
Statistics of the weather for two years to York and Moose Factories, Hudson Bay. (Appendix XI, Part C, page 93, Report of Progress for 1879-1880)
- WRIGHT, J. F.**
Rice Lake Map-area, Southeastern Manitoba. (Pages 45-88, Summary Report, 1922, Part C, G. S. C.)
- WRIGHT, J. F.**
Geology and Mineral prospects of the Northern Part of Beresford Lake Map-area, Southeast Manitoba. (Pages 86-104, Summary Report, 1923, Part B, G. S. C.)
- WRIGHT, J. F.**
Oiseau and Maskwa Rivers Copper and Copper-Nickel Deposits, Southeastern Manitoba, by J. F. Wright. (Bulletin of the Canadian Institute of Mining and Metallurgy, No 155, March, 1925, pages 220-231).



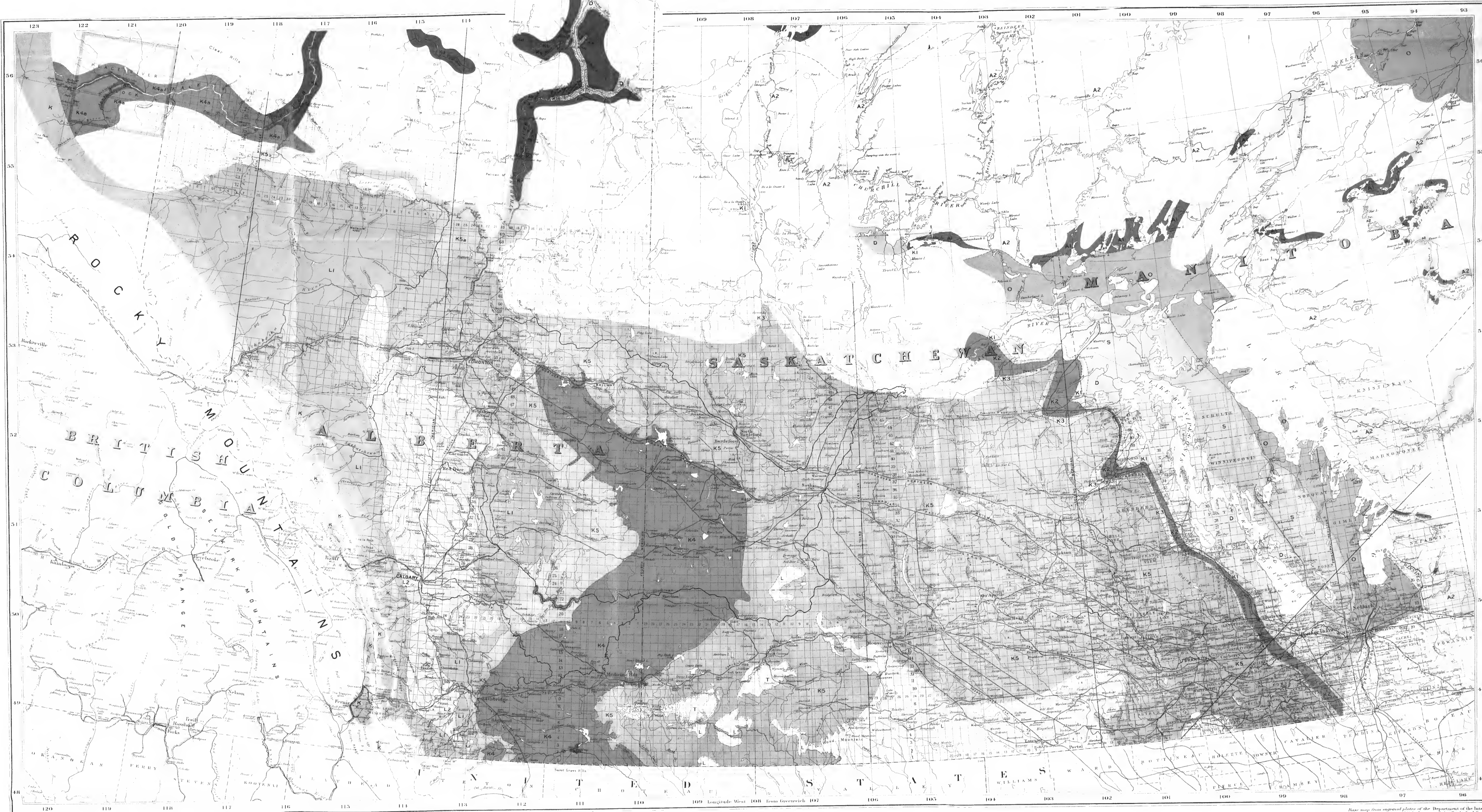
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Canada
Department of Mines
GEOLOGICAL SURVEY
Hon. L. COCHRAN, MINISTER A. PLOW, DEPUTY MINISTER
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LEGEND

TERTIARY	T	Oligocene	L	Laramie
	L2	Paskapoo	K5a	Pierre and Fort Hills (in the east only, including portions of the Canadian)
MESOZOIC	LI	Edmonton	K5a	LaBiche (Pierre section and Fort Hills)
	K5	Pierre and Fort Hills (in the east only, including portions of the Canadian)	K4a	Belly River
CRETACEOUS	K4	Belly River	K4a	Belly River
	K3	Nisqually	K4a	Belly River
PALEOZOIC	K2	Nisqually	K4a	Belly River
	K1	Nisqually	K4a	Belly River
PRE-CAMBRIAN	D	Devonian	K4a	Belly River
	S	Silurian	K4a	Belly River
A2	A2	Algonquin	K4a	Belly River
	A1	Algonquin	K4a	Belly River

Note: The term Laramie is used with the implied meaning given
by G. M. Dawson in the Report of Progress for 1888-89, p. 14.
It is a group term to include all the stratigraphically conformable
formations from the top of the Pierre to the unconformity
below the Oligocene.



C. O. Smyth, Geographer and Chief Draftsman
A. S. Jost, Draftsman

MAP 55A
Issued 1963

Geological Map
of
ALBERTA, SASKATCHEWAN AND MANITOBA

Scale: 2:250,000



To accompany Memoir No. 29

Base map from improved plates of the Department of the Interior
Geology compiled from published and unpublished maps of the Geological Survey

